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Introduction

The team's Capstone portfolio represents the **biography** of the Capstone organized around the engineering design process **EDP** components.

الـ **Capstone Portfolio** بتاع التيم هو "السيرة الذاتية" لـ Capstone كلها، ومترتب على حسب مكونات الـ Engineering Design Process اللي هي الـ **EDP**.

The Capstone portfolio is used as a source of information to prepare the Capstone Exhibition poster and contributes to the Capstone exhibition mark.

الـ Capstone Portfolio بيتستخدم كمصدر للمعلومات اللي بتجهز منها الـ Capstone Exhibition Poster، وكمان بيدخل في درجة الـ Capstone Exhibition.

- Each team has one portfolio
- The portfolio is used to gather information, both process and products, for each component of the engineering design process

الـ Portfolio بيتستخدم عشان تجمع فيه المعلومات، سواء الـ process (الخطوات اللي عملتوها) أو الـ products (النتائج والمنتجات)، لكل مكون من مكونات الـ Engineering Design Process.

- Each team is assigned a **TEAM NUMBER**
- Each team's Portfolio Name **MUST** follow this format:

Year-Semester Number-Team Number

2021-1-Team Number (example for grade 1 group #7: 2021-1-07)

- One team member sets up the portfolio following the Portfolio Template (see here: [portfolio template](#)) and makes sure all team members have access to the portfolio.

واحد من أعضاء التيم بيعمل الـ Portfolio على حسب الـ [Portfolio Template](#)، ويتأكد إن كل أعضاء التيم عندهم access عليه.

- It's always better for the **whole** team to use a shared word file to save the wasted time of gathering the tasks of every member at the end of the semester

دائماً الأحسن إن التيم كله يشتغل على word file مشترك (shared)، عشان توفر الوقت اللي بيضيع في آخر الترم وانتوا بتجمعوا شغل كل واحد لوحده.

Obligatory Rules | قواعد إجبارية

Throughout writing the **Capstone Portfolio**, You **Must** follow these rules:

- 1) Follow the **Capstone Portfolio Template** and include a **Table of Contents** at the start.

امشي على الـ **Capstone Portfolio Template** وحط **Table of Contents** في أول الـ **Portfolio**.

- 2) Validate your Ideas with statistics, graphs, figures. For example you said that electronic waste is increasing in high amounts every year, you must **validate** that information with statistics and graphs from **Trusted** Resources like Sites that ends with .gov .org .us .uk except wikipedia. try to avoid most of .com sites. Also, research papers (most of them are in .com or .net sites but that's valid)

أثبت أفكارك بإحصائيات ورسوم بيانية وأشكال. يعني مثلاً لو قلت إن electronic waste بيزيد بكميات كبيرة كل سنة، لازم تثبت المعلومة دي بإحصائيات وgraphs من مصادر موثوقة زي المواقع اللي بتخلص بـ .gov و .org و .us و .uk، ماعدا Wikipedia. وحاول تبعد عن أغلب مواقع الـ .com.

والـ research papers كمان مصادر كويسة (أغلبها موجود على مواقع .com أو .net بس ده مقبول).

Improve the Scientific and Technological Environment for all

With the rising global population, the world has observed an increase in the adoption of innovative technologies. With every technological advancement, people have shifted towards newer electronics. According to the Global E-waste Monitor (c. 2024), the global generation of e-waste has surpassed 65 billion tons, resulting in the discarding of old electronic products. The discarded E-waste processes harmful toxicants like heavy metals, non-ferrous substances, microplastics, glass, and others, causing serious implications to the environment, including land, water, and air, which raises concern towards the health and ecosystem.

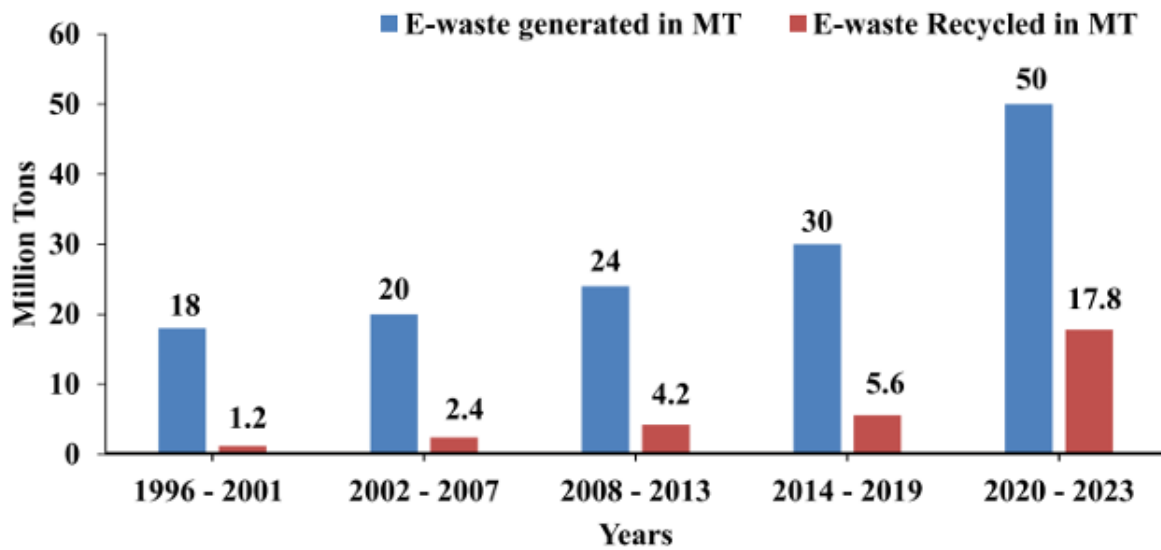


Figure 1.6 - Electronic waste generated compared to the amount of recycled waste.

- 3) Number and label graphs, figures and tables (Label graphs and figures below them, but label tables above). Number in this format (Figure, Table or Graph, chapter's number. The figure's number). For example if you number the 5th Figure in the second chapter it will be **Figure 2.5**. notice that the number of the graph is independent of the number of tables or figures. So if you have a table after two figures and a graph it will still be **Table 1.1**. Label with one small sentence that illustrate what is shown in the figure as you can see in the previous picture.

رَقْمٌ وَسَمِي (label) الـ graphs والـ figures والـ tables. الـ label بتاع الـ graphs والـ figures بيتكتب تحتها، أما الـ tables فالـ label بيتكتب فوقها. والترقيم بيكون بالشكل ده: (Figure) أو Table أو Graph، رقم الـ chapter. رقم الشكل). يعني مثلاً لو بترقم الـ Figure الخامسة في الـ chapter الثاني هتبقى **Figure 2.5**. وخلي بالك إن ترقيم الـ graphs مستقل عن ترقيم الـ tables والـ

figures؛ يعني لو عندك table جاي بعد اتنين figures و graph، برضه هيبقى **Table 1.1**. وال label يبقى جملة صغيرة بتوضح الشكل بيعرض إيه، زي ما شايف في الصورة اللي فوق.

- 4) Save all sites as you write because you will need to write them in APA7 format at the end of the portfolio. Send them in a group or save them in a word file as you please.

احفظ كل المواقع اللي بتاخذ منها أول بأول، لأنك هتحتاج تكتبها بصيغة APA7 في آخر الـ Portfolio. ابعثها على جروب أو احفظها في word file، زي ما تحب.

- 5) Cite as you write. write in text citation in APA7 format. You write according to the "organization" then in parentheses the Author (or the organization) and the date, then the statistic you can see in the aforementioned picture, or you can write the statistic first and following it in parentheses lies the Author or the organization and the date for example: (World Bank, 2022) or (Ahmed & Mohammed, 2019).

اعمل citation وانت بتكتب على طول. اكتب الـ in-text citation بصيغة APA7: يا إما تكتب "according to" وبعدين بين قوسين اسم الـ Author أو الـ organization والسنة، وبعدين الإحصائية (زي ما شايف في الصورة اللي فوق)، يا إما تكتب الإحصائية الأول وبعدها بين قوسين الـ Author أو الـ organization والسنة، زي كده: (World Bank, 2022) أو (Ahmed&Mohammed, 2019).

General Non Obligatory Tips | نصائح عامة مش إجبارية

Throughout writing the **Capstone Portfolio**, some tips will help you:

- 1) Justify (as in "to click **Ctrl+J**") all body paragraphs.
- 2) Use **Times New Roman** as the primary font for the **Capstone Portfolio**
- 3) Set the body font size to 14 points in the **Capstone Portfolio**.
- 4) Write in the **Passive** and **avoid** using any personal pronouns (e.g., I, you, he, she, we, us, him, her, his, hers, its, theirs, our, and your).

اكتب بصيغة المبني للمجهول (**Passive**) وابتعد خالص عن الضمائر الشخصية (زي: I, you, he, she, we, us, him, her, his, hers, its, theirs, our, your).

- 5) Make use of online grammar checkers (see **Grammarly**, which you can get as an add-in for Microsoft Word) to ensure the quality of your writing.

استخدم أدوات تصحيح القواعد اللي على النت (زي **Grammarly**، ويمكن تنزله كـ add-in على Microsoft Word) عشان تضمن جودة كتابتك.

- 6) Do **NOT** plagiarise, and make sure your writing is original by using a plagiarism checker.

ماتعملش plagiarism (نقل حرفي)، واتأكد إن كتابتك أصلية باستخدام plagiarism checker.

- 7) Use multiple Examples To better illustrate your idea.

استخدم أمثلة كثير عشان توضح فكرتك أحسن.

Egypt Grand Challenges

Egypt Grand Challenges are the first things you begin working on in the portfolio and in general.

It lays the foundation for everything you work on moving forward, therefore you have to make sure you do it correctly to avoid any issues or setbacks in the future.

دي الأساس اللي هيتبني عليه كل حاجة بعد كده، عشان كده لازم تتأكد إنك عاملها صح عشان ماتقابلش مشاكل أو تأخير قدام.

The capstone challenge picks 4 mandatory grand challenges (out of 11) that you must discuss.

الـ capstone challenge بيحدد 4 grand challenges إجبارية (من أصل 11 لازم تتكلم عنهم).

NOTE that you can not discuss less, but it is possible to discuss more than 4. However, going overboard with the amount can lead to more mistakes or possible disorder when moving to later sections (such as the section known as “problem to be solved” which connects all of them to a root cause)

خد بالك إنك ماينفعش تتكلم عن أقل من 4، بس ينفع تتكلم عن أكثر. لكن لو زودتها أوي ممكن ده يوقعك في أخطاء أكثر أو لخبطة لما تيجي للأجزاء اللي بعد كده (زي الجزء اللي اسمه "problem to be solved"، اللي بيربطهم كلهم بـ root cause واحد).

Egypt's 11 grand challenges are:

الـ 11 grand challenges بتوع مصر هما:

- | | |
|--------------------------------|--------------------------------------|
| 1- Alternative Energies | 2-Population Growth |
| 3- Garbage and Waste/Recycling | 4- Arid Areas |
| 5- Urban Congestion | 6- Environmental Pollution |
| 7- Clean Water | 8- Industrial and Agricultural Bases |
| 9- Public Health | 10- Science and Technology |
| 11- Climate Change | |

For starters lets look at the necessary formatting and what you must discuss. First, you need to have **an overview** or introduction to the grand challenge, in there you discuss

what it means, major concepts (for climate change for example explain the green house effect and how it works), and you set the pace for the next sections.

في البداية علينا أن نشوف الشكل المطلوب والحاجات اللي لازم نتكلم عنها. أول حاجة لازم يكون عندك **overview** أو مقدمة عن الـ **grand challenge**، تشرح فيها يعني إيه، والمفاهيم الأساسية فيه (يعني مثلاً في الـ **climate change** تشرح الـ **greenhouse effect** وبيشتغل إزاي)، وتمهّد للأجزاء اللي بعدها.

Next up are **the causes and impacts**, these sections are crucial and basically the core of your starting argument. You must discuss at least 3 causes and 3 impacts, they aren't interchangeable so you must have at least 6 total talking points at the end. It is strongly advised to interchange between "impact if the problem remains unsolved" and "impact if it did get solved" (note that you CAN NOT mention a solution or a possible method in any of these.) You can't mention one point in both types of impacts, for example;

بعد كده تيجي الـ **causes** والـ **impacts**، ودول أجزاء مهمة جداً وهما قلب الحجة اللي بتبدأ بيها. لازم نتكلم عن 3 causes على الأقل و 3 impacts على الأقل، ومش بيبندلوا مع بعض، يعني في الآخر لازم يكون عندك 6 نقاط على الأقل. ويُفضّل جداً إنك تتوّع بين "impact if the problem remains unsolved" و "impact if it did get solved" (وخلي بالك إنك ماينفعش تذكر أي solution أو طريقة حل في أي نقطة منهم). وماينفعش تذكر نفس النقطة في النوعين، زي المثال ده:

"if this problem remains as is, we expect a rising trend in traffic and disease spread"

"if this problem gets solved, data trends suggest a decrease in road congestion and disease transmission"

These two are the same no matter how much you reword them so just look for a different talking point.

الجمليتين دول نفس الفكرة مهما غيّرت في صياغتهم، فدور على نقطة ثانية مختلفة.

In these two sections you **MUST** show urgency and keep your reader hooked and focused therefore, during your research you have to find the most engaging and interesting pieces of information. For example, if you are talking about population growth, don't mention longer traffic times as an impact. Instead, mention the increased number of disease spread or malnutrition due to lack of resources.

في الجزئين دول لازم تبين إن الموضوع عاجل (urgency) وتفضل شادد انتباه القارئ ومركّزه؛ عشان كده وانت بتعمل research لازم تدور على أكثر معلومات جذابة ومثيرة للاهتمام. يعني مثلاً لو بتتكلم عن **population growth**، ماتقولش إن زمن الزحمة المرورية زاد كـ **impact**، لكن قول إن انتشار الأمراض زاد أو سوء التغذية زاد بسبب نقص الموارد.

If you haven't noticed by now, they are called challenges but not straight up problems—population growth isn't an issue, but it is challenging to keep up with it; if the necessary resources to satisfy needs aren't available. So, you must avoid biases against a challenge even if you support solving it. Think about recycling for a moment, everyone advises to do it and obviously we would be biased towards it, but it would be advantageous to also discuss the economical challenges, financial drawbacks and educational deficiency in regards to recycling. This could help push your discussion from just finding a solution, to finding a genuine applicable solution that could overcome these issues, a quick tip and nice way to stay on track is to imagine someone arguing and debating every sentence you type. You will have to discuss these individual issues in later sections (predominantly Chapter 2)

لو ماكنتش لاحظت لحد دلوقتي، دي اسمها **challenges** مش **problems** على طول. الـ population growth في حد ذاته مش مشكلة، لكن التحدي هو إننا نلاحق عليه لو الموارد اللي بتسد الاحتياجات مش متوفرة. عشان كده لازم تبعد عن التحيز ضد أي challenge حتى لو انت مع حله. فِكر في الـ recycling مثلاً: الكل بينصح بيه وأكد هنبقى متحيزين ليه، بس هيبقى في صالحك إنك تتكلم كمان عن التحديات الاقتصادية والعيوب المادية ونقص التوعية المرتبطين بيه. ده ممكن ينقل كلامك من مجرد "إيجاد حل" لـ "إيجاد حل حقيقي قابل للتطبيق" يتغلب على المشاكل دي. ونصيحة سريعة تخليك ماشي صح: تخيل إن فيه حد بيجادل في كل جملة بتكتبها. وهتحتاج تتكلم عن المشاكل دي بالتفصيل في أجزاء بعد كده (غالباً في Chapter 2).

Lastly, Justification/Reasoning. This section is optional and not mandatory whatsoever. In this one you can build up the argument to why you believe it is necessary to look into a solution for this grand challenge or pursue it in terms of future aspirations. You can separate your "impacts if problem is solved" under this section and mix them around with some qualitative data as well as articles regarding future plans or investigations of growing trends.

وأخيراً الـ **Justification/Reasoning**، والجزء ده اختياري ومش إجباري خالص. فيه بتبني الحجة ليه شايف إنه ضروري ندور على حل للـ grand challenge ده، أو ليه تكمل فيه من ناحية الطموحات المستقبلية. وممكن تحط الـ "impacts if problem is solved" تحت الجزء ده، وتخلطها بشوية qualitative data ومقالات عن الخطط المستقبلية أو دراسات عن الاتجاهات اللي بتزيد.

When you first begin research in regard to the specific topic and grand challenge there are some general ground rules that we recommend following to make it as efficient as possible:

أول ما تبدأ الـ research عن الموضوع والـ grand challenge، فيه شوية قواعد عامة بننصح بيها عشان تخلي شغلك أكفأ ما يمكن:

- (1) Quantitative data > Qualitative data. When discussing topics such as population growth and urban congestion saying that “most streets are crowded and full of traffic” isn’t as strong as “The population density in Egypt reached 118 citizens/Km² with only 7.7% of Egypt’s area being actually occupied”.

Quantitative data > Qualitative data، يعني الأرقام أقوى من الوصف. لما تتكلم عن

مواضيع زي population growth و urban congestion، إنك تقول

"most streets are crowded and full of traffic"

مش قوية زي إنك تقول

"The population density in Egypt reached 118 citizens/Km² with only 7.7%
.of Egypt’s area being actually occupied"

- (2) Referencing and comparing. If you noticed just now, it isn’t clear how bad Egypt’s population distribution is, it makes you ask the question “how bad is this?” or wonder what it really means, that is why it is really beneficial to cite standards presented by the United Nations, for example;

Referencing and comparing (الرجوع لمعيار والمقارنة بيه). لو لاحظت دلوقتي، مش واضح

قد إيه توزيع السكان في مصر وحش؛ الرقم لوحده بيخليك تسأل "طب ده وحش لدرجة إيه؟" أو تستغرب هو يعني إيه أصلاً. عشان كده مفيد جداً إنك تستشهد بالمعايير اللي بتحطها الأمم المتحدة مثلاً، زي كده:

"The United Nations stated that the safe maximum population density for a country with Egypt’s resources should average around 90 citizens/Km² which means our population density is over the standard by 20+ citizens/Km²"

For other topics like pollution, you might find yourself citing different types of data like annual death rates or death causes due to a specific issue, these don’t need any type of comparison to a certain standard because it is very intuitive that you wouldn’t want anyone dying due to unnatural causes or circumstances.

في مواضيع تانية زي pollution ممكن تلاقي نفسك بتستشهد بأنواع تانية من الداتا، زي معدلات الوفيات السنوية أو أسباب الوفاة بسبب مشكلة معينة. دي مش محتاجة مقارنة بمعيار معين، لأنه طبيعي ومفهوم إنك مش عايز حد يموت مهما كانت الأسباب أو ظروف غير طبيعية.

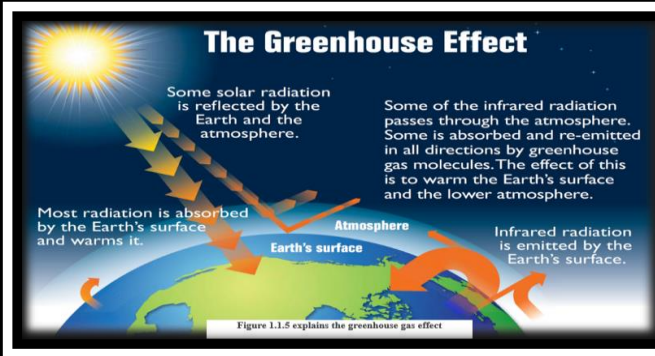
- (3) Illustrations and Figures. These are mostly mandatory but very easy to complete. Any type of figure or table—that helps illustrate the urgency or help a reader visualize and render the concept better—works. These could come in the form of a graph showcasing a study you cited for its quantitative data, an image that helps

explain a concept, or a qualitative image beside a piece of data to give more clarity. A few examples are shown in the following figures:

Illustrations and Figures (الرسومات والأشكال). دي غالباً إجبارية بس سهلة جداً. أي figure أو table بيساعد يوضح إن الموضوع عاجل، أو بيساعد القارئ يتخيل ويفهم الفكرة أحسن، ينفع. ممكن تكون graph بيعرض دراسة استشهدت بالـ quantitative data بتاعتها، أو صورة بتشرح مفهوم، أو صورة توضيحية جنب رقم معين عشان توضحه أكثر. وفيه أمثلة في الأشكال اللي تحت:

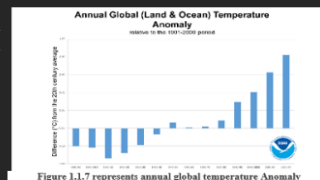
Our steps towards achieving these goals are more urgent than they are important. This urgency is evident in analyzing the World Health Organization report, which states that 9 out of 10 people worldwide breathe air that exceeds the WHO guideline limits. Thus, more than 12.5% of global deaths are attributable to air pollution. Consequently, Air pollution is now considered the second leading risk for global deaths. Pollution damages extend to harm ecosystems and biodiversity, which contributes to nature-related economic risks of USD 5 trillion or more. Moreover, the World Bank estimates USD 6 trillion/year as the cost of air pollution health damages, which is equivalent to about 5% of global GDP.

Therefore, we must acknowledge that pollution, with its far-reaching consequences, poses a significant challenge to our planet, jeopardizing its health, environment, economy.



Hotter temperatures: As greenhouse gas concentrations rise, so does the global surface temperature. The last decade, **2011-2020**, is the warmest on record. Since the **1980s**, each decade has been warmer than the previous one, as represented in Figure 1.1.7. Nearly all land areas are seeing more hot days and heat waves. Higher temperatures increase heat-related illnesses and make working outdoors more difficult. Wildfires start more easily and spread more rapidly when conditions are hotter. Temperatures in the Arctic have warmed at least twice as fast as the Global average.

Increase drought: Climate change is changing water availability, making it scarcer in more regions. Global warming exacerbates water shortages in already water-stressed



Problem To Be Solved

This is the second section following the grand challenges. This is arguably more important than the grand challenges because failure to complete this concisely will most likely spiral into more mistakes further down the line. In general the problem to be solved should be addressing the following questions:

ده الجزء الثاني بعد الـ grand challenges، ويمكن نقول إنه أهم منهم كمان، لأن لو ماعملتوش بشكل دقيق ومختصر غالباً هيجزّ وراه أخطاء أكثر قدام. وبشكل عام الـ problem to be solved لازم يجاوب على الأسئلة دي:

- What specific problem are you addressing?

إيه المشكلة المحددة اللي انت بتتعامل معاها؟

- What are the impacts or consequences that are related to dealing with that problem?

إيه الـ impacts أو النتائج المرتبطة بالتعامل مع المشكلة دي؟

- Explain The major positive -if problem solved- and negative -if not solved- impacts (also can be useful in journals)

اشرح أهم الـ impacts الإيجابية (لو المشكلة اتحلّت) والسلبية (لو ماتحلّتش) (ودي كمان ممكن تفيدك في الـ journals).

There is a common **misunderstanding** of the difference between **Grand Challenges** and the **problem to be solved**. Egypt's Grand Challenges can contain many **sub-problems** that are technically obsolete and practically impossible to completely solve or wipe the stain the left on Egypt.

فيه لبس شائع في الفرق بين الـ **Grand Challenges** والـ **problem to be solved**. الـ Egypt Grand Challenges ممكن يكون جواها **sub-problems** كثير، فرعية ومتشعبة، ومن المستحيل عملياً إنها تتحل بالكامل أو إنك تمسح أثرها اللي سابته على مصر.

On the other hand, the problem to be solved is a specific problem that can be a **connection** between more than one Grand Challenge or a sub-problem from a Grand Challenge which can be considerably solved if enough effort and work is dedicated. That's

why we start with the grand challenges, we discuss them and connect them to a root cause, that is presumably our problem to be solved.

على الناحية الثانية، الـ problem to be solved هي مشكلة محددة ممكن تكون حلقة وصل بين أكثر من Grand Challenge، أو sub-problem من Grand Challenge واحد، وممكن تتحل بدرجة كبيرة لو اتبذل فيها مجهود وشغل كفاية. وعشان كده بنبدأ بالـ grand challenges: بنتكلم عنهم ونربطهم بـ root cause، والـ root cause ده غالباً هو الـ problem to be solved بتاعنا.

Think of it like this, you have two factories, one produces one byproduct and the other produces 4 byproducts, it would be better to fix the second one to limit its dangers and side effects on its environment.

فكّر فيها كده: عندك مصنعين، واحد بيطلع byproduct واحد، والتاني بيطلع 4 byproducts؛ أكيد الأحسن إنك تصلح التاني عشان تقلل خطره وآثاره الجانبية على البيئة اللي حواليه.

For example, in G11 S1 we had four **main** Grand challenges in the challenge:

مثلاً في G11 S1 كان عندنا 4 Grand challenges أساسيين في الـ challenge:

1. Improve the scientific and technological environment for all.
2. Address and reduce pollution fouling our air, water, and soil.
3. Reduce and adapt to the effects of climate change.
4. Recycle garbage and waste for economic and environmental purposes.

And the challenge was making a fully functional device that can be used in school labs utilizing scraps from old discarded devices. So, **labeling** "Improve the scientific and technological environment for all" as our problem to be solved is very **broad** and inaccurate. The average reader would not recognize what **specific** problem I am solving. So instead, we chose found a stronger label which was "wasting electronics containing heavy, hazardous metals, resulting in much pollution,". It works well because it is much more specific and connects all 4 of the grand challenges with each other.

والـ challenge كان إننا نعمل جهاز شغال بالكامل ينفع يتستخدم في معامل المدرسة، ونستخدم فيه خردة من أجهزة قديمة مرمية. فلو سمّينا الـ problem to be solved بتاعتنا "Improve the scientific and technological environment for all" هيبقى كلام واسع جداً ومش دقيق، والقارئ العادي مش هيعرف إيه المشكلة المحددة اللي بنحلها. فبدل كده اخترنا تسمية أقوى وهي "wasting electronics containing heavy, hazardous metals, resulting in much pollution" ودي نفعت لأنها محددة أكثر بكثير وتربط الـ 4 grand challenges ببعض.

The problem to be solved is split into 4 divisions: | Problem to be solved

بيتقسم لـ 4 أجزاء

- Overview

- What specific problem are you addressing?

إيه المشكلة المحددة اللي انت بتتعامل معاها؟

This is the first question for you to address and in here you introduce the whole problem to be solved.

ده أول سؤال لازم تجاوب عليه، وفيه بتقدّم الـ problem to be solved كلها.

- You can use multiple paragraphs in the "**Overview**" section; however, you should avoid writing figures, tables, or equations in it (That does **not** mean avoiding evidence. Statistics must appear inside the text with APA 7 in-text citations.).

ينفع تكتب كذا فقرة في جزء الـ **Overview**، بس ابعد عن إنك تحط فيه figures أو tables أو equations (وده مش معناه إنك تبعد عن الأدلة؛ الإحصائيات لازم تيجي جوه الكلام نفسه ومعاها APA 7 in-text citations).

- Try starting with the broad idea of two or three main Egypt Grand Challenges and then arriving at a more specific idea by mentioning the main connection between these **Grand Challenges**. Then, you would try to make this connection more specific to reach the **Problem to Be Solved**. Your goal is to pave the way for the upcoming parts.

حاول تبدأ بالفكرة العامة لاتنين أو ثلاثة من الـ Egypt Grand Challenges الأساسيين، وبعدين توصل لفكرة أدق لما تذكر حلقة الوصل الأساسية بين الـ **Grand Challenges** دول. وبعد كده تحاول تخلي حلقة الوصل دي أكثر تحديداً لحد ما توصل للـ **Problem to Be Solved**. هدفك إنك تمهّد للأجزاء اللي جاية.

- State the problem in one sentence.

اكتب المشكلة في جملة واحدة.

- End the Overview with one clear sentence, written in bold, following this template:

اختم الـ Overview بجملة واحدة واضحة، مكتوبة **bold**، ماشية على الـ template ده:

The problem to be solved is [the harmful condition] affecting [who or where in Egypt], caused by [the main driver], resulting in [measurable harm].

- This exact sentence must then be reused, word for word, in the Abstract and the Introduction in the capstone poster.

الجملة دي بالظبط لازم تتكرر بعد كده، كلمة بكلمة، في ال Abstract وال Introduction بتوع ال capstone poster.

- **Justification of the problem**

- This part is practically mandatory, but it is optional in the sense that you can split it into its own division (justification), other than that, it is basically an extension to the overview.

الجزء ده عملياً إجباري، بس اختياري بمعنى إنك ممكن تفصله في جزء لوحده اسمه justification؛ غير كده هو امتداد لل overview.

After you've completed the overview you should begin discussing why you chose this problem in **particular**. Mention its **importance** and **severity** and how its influence or impact affects a broad number of people and locations specific to Egypt.

بعد ما تخلص ال overview تبدأ تتكلم ليه اخترت المشكلة دي بالذات. اذكر أهميتها وخطورتها، وإزاي تأثيرها بيطول عدد كبير من الناس وأماكن كثير في مصر تحديداً.

- **Positive impacts,**

- **Explain** the major positive (if the problem is solved), this count as issues that are predicted to stop once the problem is dealt with or possible advantage that could arise in general. For example "solving the food shortage in Egypt could allow workers to have more energy and capacity for work, as studies show, well fed workers exert a 15% higher efficiency at work, which also makes sense biologically."

اشرح أهم ال impacts الإيجابية (لو المشكلة اتحلت)، ودي بتشمل المشاكل المتوقع إنها تقف لما المشكلة تتحل، أو أي مميزات ممكن تظهر بشكل عام. مثلاً: "solving the food shortage in Egypt could allow workers to have more energy and capacity for work, as studies show, well fed workers exert a 15% higher efficiency at work, which also makes sense biologically."

- listing **3-4** positive consequences (each in a paragraph). **Do not** write the impact by itself explaining it in **at least 2-3 lines**.

اكتب من 3 لـ 4 نتائج إيجابية (كل واحدة في فقرة). وامتدش الـ impact لوحده، لازم تشرحه في سطرين لتلاتة على الأقل.

- **Negative consequences**

- Discuss the possible and predicted negative (if the problem is not solved) consequences. These are based on things that are already happening not literally only going to happen in the future; an increase or them staying in effect are probable and plausible points. For example, "If food shortage isn't dealt with, it is predicted that the [30 deaths per 1000 citizens] death rates due to starvation and malnutrition will keep on existing with the possible chance of increasing as demand ultimately increases with supplies decreasing ever so slowly."

اتكلم عن النتائج السلبية المحتملة والمتوقعة (لو المشكلة ماتحلتش). ودي مبنية على حاجات بتحصل فعلاً دلوقتي، مش حاجات هتحصل في المستقبل بس؛ يعني إنها تزيد أو تفضل مستمرة ده كلام منطقي ومقبول. مثلاً:

"If food shortage isn't dealt with, it is predicted that the [30 deaths per 1000 citizens] death rates due to starvation and malnutrition will keep on existing with the possible chance of increasing as demand ultimately increases with supplies decreasing ever so slowly."

- Mention **3-4** negative consequences (each in a paragraph) whilst explaining each one well enough in at least 2-3 lines.

اذكر من 3 لـ 4 نتائج سلبية (كل واحدة في فقرة) واشرح كل واحدة كويس في سطرين لتلاتة على الأقل.

Important notes: | ملاحظات مهمة

- **Avoid** using multiple paragraphs, figures, or tables in a single consequence.

ابعد عن إنك تكتب كذا فقرة أو figures أو tables في consequence واحدة.

- **Avoid** repeating the same impact in positive and negative forms and just inverting it. For example, do not mention "Reduced Greenhouse Emissions" as a positive consequence and then mention "Greenhouse Effect" as a negative consequence.

ابعد عن تكرار نفس الـ impact في الشكل الإيجابي والسلبي وخلاص تقلبه. يعني مثلاً ما تذكرش "Reduced Greenhouse Emissions" كـ positive consequence وبعدين تذكر "Greenhouse Effect" كـ negative consequence.

- **Positive impacts are not the advantages of your prototype.** This section describes what improves in Egypt if the problem is solved by any means, by anyone. Writing "our device is cheap and portable" here is a scope error; that belongs to *Selection of Solution*

الـ **Positive impacts** مش هي مميزات الـ **prototype** بتاعك. الجزء ده بيوصف إيه اللي هيتحسن في مصر لو المشكلة اتحلت بأي طريقة وعلى أي حد. لو كتبت هنا "our device is cheap and portable" تبقى غلطت في النطاق (scope error)؛ الكلام ده مكانه في * Selection of Solution*.

- you must include statistical information to back up your claims and strengthen your points. If you simply go "our problem to be solved is CO₂ emissions because people die due to intoxication", that won't be sufficient compared to "our problem to be solved is CO₂ emissions as they are a primary cause in the intoxication and death of 27.3 people for every 1000 people."

لازم تحط معلومات إحصائية تدعم كلامك وتقوي نقاطك. لو قلت ببساطة "our problem to be solved is CO₂ emissions because people die due to intoxication" مش هيبقى كفاية، مقارنة بـ "our problem to be solved is CO₂ emissions as they are a primary cause in the intoxication and death of 27.3 people for every 1000 people."

- Graphs and figures in the positive and negative consequences are highly advised and technically mandatory. They also help the reader get a better sense of urgency and severity whilst helping them understand through visuals.

الـ graphs والـ figures في الـ positive والـ negative consequences منصوح بيها جداً وتقريباً إجبارية. وكمان بتساعد القارئ يحس أكثر بالعجلة والخطورة، وبتسهّل عليه الفهم بالصور.

Research

Research here means one of two things:

- Documenting concepts/problems/ideas/devices you search about

توثيق المفاهيم/المشاكل/الأفكار/الأجهزة التي بتدور عليها.

- Documenting results from little thought processes, operations and or simulations you run.

توثيق نتائج تفكير بسيط أو عمليات أو simulations بتعملها.

Research is a *really* flexible section, meaning that it just requires you to just know what you're writing about and requires you on your own to know what you want to write about and how to divide one topic into multiple, simpler topics.

الـ Research جزء مرن *جداً*؛ يعني هو محتاج منك بس إنك تكون فاهم انت بتكتب عن إيه، وإنك بنفسك تعرف عايز تكتب عن إيه، وإزاي تقسم موضوع واحد لكذا موضوع أبسط.

When starting off your research, you'll probably want to write about your design requirements, and keywords used in the challenge file, this makes sense because that way you'll be able to cover the most vast ground in relation to the challenge so that you have a deeper understanding on what to research later.

في بداية الـ research غالباً هتحب تكتب عن الـ design requirements والـ keywords اللي في الـ challenge file، وده منطقي لأنك كده هتغطي أوسع مساحة مرتبطة بالـ challenge، فيبقى عندك فهم أعمق للي محتاج تعمل عنه research بعد كده.

Later during your research, you might encounter a simulation application/mathematical model/predictive model, using one of the three, you can experiment with your prototype and gain valuable information regarding your prototype. An example of this was using a bridge simulation application to find out which truss frame shape is generally better for a bridge, a rectangular or a square frame; I tried both, documented the results into tables recorded in the Research section, and gave a definitive conclusion relating to the research or result given by the simulation app.

بعد كده وانت بتعمل research ممكن تقابل simulation application أو mathematical model أو predictive model؛ وباستخدام أي واحد منهم تقدر تجرب على الـ prototype بتاعك وتطلع بمعلومات قيمة عنه. مثال على كده: استخدام bridge simulation application عشان نعرف أنه شكل truss frame أحسن للكوبري عموماً، rectangular ولا square frame؛ جربت الاثنين، ووثقت النتائج في tables في جزء الـ Research، وطلعت باستنتاج نهائي مرتبط بالـ research أو بالنتيجة اللي طلعتها الـ simulation app.

Research about the problem looks like this, for example: | مثال

Research about the problem

Electronic waste

In the last century, humans faced the electronic revolution, which is still advancing until now. But the same mistake that humans make every time is happening now, where these electronics contain hazardous materials, especially in the PCBs, and due to the fast advancement of the technology, people change their electronic devices rapidly, which makes the electronic waste stream the fastest-growing solid waste stream. The United Nations came up with the phrase “e-waste tsunami” to describe the critical situation of electronic waste. By 2021, the total amount of electronic waste reached 57.4 million tons, and it is predicted that the growth rate will be at least 2 MT per year. Moreover, the experts estimate that there will be a total of 347 metric tons of non-recycled electronic waste by the end of the current year. Only 17.4% of the e-waste is collected and recycled, and the percentage is small and less than the quarter because of the complexity of recycling the electronic waste and its high operational costs.

When researching about your prior solutions, you’ll definitely want to find out their scientific base, or when you’ve come to terms with your team on a solution, you’ll want to research the scientific base upon which the solution works, examples of this are:

لما تعمل research عن الـ prior solutions أكيد هتحب تعرف الـ scientific base بتاعتها (الأساس العلمي)، أو لما تتفق مع التيم على solution هتحب تعمل research عن الأساس العلمي اللي الحل ده شغال عليه. وأمثلة على ده:

Fundamental Principles

The conductivity meter is based on the principle of electricity, where electrons flow through a conductor when a potential difference is applied. The magnitude of the current flowing through the conductor depends on the resistance of the conductor.

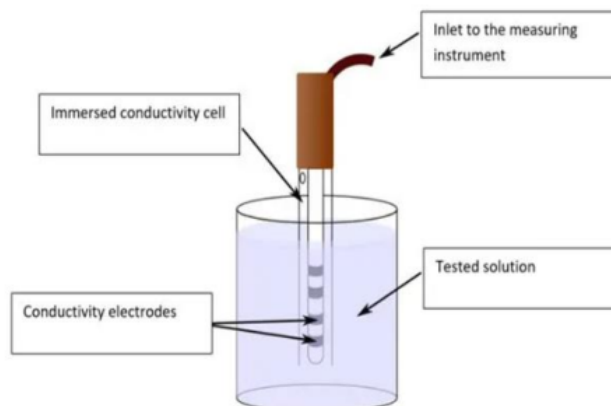


Figure 1.8 A diagram of a standard conductivity meter

The conductivity meter mainly consists of two electrolytes, as shown in **Figure (1.8)**, one positive and the other negative, and the distance between them is usually equal to 1 cm. They are immersed in the solution that is being measured. When the electrical current is detected, the system starts to measure the current flow through the solution. The higher the concentration, the higher the conductivity, and it is also affected by the temperature and the factors that affect the solubility, as mentioned before.

Bias Circuits

In general, bias circuits are used to set the **ground level** of a signal, as in, specifying that the reference **voltage** or the **ground** is x volts, where x is the reference voltage. Any voltage above this reference line is therefore considered a **positive voltage**, and anything below it is considered a **negative voltage**.

Something like a **transistor** for example relies on a **concept of current gain**, and that in on itself in **AC signals** requires the very same process **bias circuits** perform – “**biasing**” because otherwise, the **linearity** or **proper function** of the **transistor** will be **broken** and will give an **unpredictable output**.

Voltage dividers can pave the **pathway** towards a **high bias stability**. This is called a **voltage divider bias**.

Figure (1.47) shows this bias in a circuit using a **transistor**.

We're not as concerned by this as we are concerned with a bias in an **op-amp**, therefore, the main focus will be for **op-amps**.

Mainly, this is done so the **op-amp** doesn't reach its point of saturation nor does an **error happen** in the **analog-to-digital** conversion phase in the **microcontroller (ATMega328P-U)**, if the signal were purely driven into the A/D converter, the entire resolution of data would not appear or be input into the processing stage.

In the case of **biasing an op-amp**, there exist only **three common configurations** that can be used, and these depend on whether the **op-amp is inverting, non-inverting, or differential**. These **configurations** have **two possible outcomes** in terms of **biasing**, and that is **DC- or AC-coupling**. For each op-amp configuration, the **DC-coupling** allows every signal to pass through; however, this makes it more **difficult to bias**, as there may be both an AC and a DC signal at the same time. On the other hand, **AC-coupling** blocks out the **DC signal** and leaves the **AC signal** as

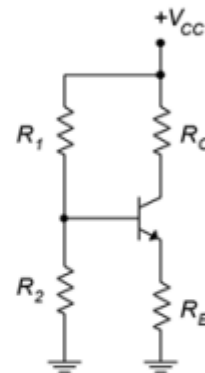


Figure 1.47 – a voltage divider as a bias circuit in a transistor circuit.

When researching, you need to look into unconventional places. You're going to want to search in research papers, use archive.org for offline pages/pages that have been taken down, forums (engineering forums, something like stack overflow, etc., etc.).

وانت بتعمل research لازم تدور في أماكن مش تقليدية. هتحتاج تدور في الـ research papers، وتستخدم archive.org للصفحات اللي اتشالت أو مابقتش أونلاين، والـ forums (زي engineering forums، أو حاجة زي Stack Overflow، وهكذا).

When doing experiments or documenting results, you'll need to write how to actually perform those methods and or discover how to do these methods, which you'll most likely document in the research section aswell.

لما تعمل تجارب أو توثق نتائج، هتحتاج تكتب إزاي تنفذ الطرق دي فعلاً، أو تكتشف إزاي تعملها، وده غالباً هتوثقه في جزء الـ research برضه.

NOTE: The research section is heavily variable between teams and writing styles differ between team members themselves, variation is 100% bound to happen in the research section.

ملحوظة: جزء الـ research بيختلف جداً من تيم للتاني، وأسلوب الكتابة بيختلف حتى بين أعضاء التيم نفسه، فالاختلاف في جزء الـ research هيجصل 100%.

المجالات اللي تعمل عليها | Areas to reconsider doing research for: Research

- 1- Research about the problem

Research عن المشكلة.

- 2- Research about the scientific base

Research عن الأساس العلمي (scientific base).

- 3- Research about used materials and other components you didn't use

Research عن الخامات المستخدمة والمكونات التانية اللي ماستخدمتهاش.

- 4- Research about other methods and solutions

Research عن الطرق والحلول التانية.

- 5- Research about construction methods and used tools and circuitry

Research عن طرق التصنيع والأدوات والدوائر الكهربائية المستخدمة.

Prior solutions/other solutions already tried

This is the fourth section for you to start working on. It is advised to complete this section over the first 3-4 weeks of capstone work.

ده الجزء الرابع اللي تبدأ تشتغل عليه، ومنصوح إنك تخلصه في أول 3-4 أسابيع من شغل الـ capstone.

Although this section is moderately simple, you must not let this simplicity distract you from its sheer importance. In general, you are expected to discuss and write about 3-4 prior solutions, writing about more is allowed but not advised [you must spend your time carefully on what is deemed mandatory for you work on instead.]

ورغم إن الجزء ده بسيط نسبياً، ماتخليش بساطته تلهيك عن أهميته الكبيرة. وبشكل عام المتوقع منك إنك تتكلم وتكتب عن 3-4 prior solutions؛ الكتابة عن أكثر مسموحة بس مش منصوح بيه [لازم تصرف وقتك بحرص على الحاجات الإجبارية اللي مطلوب تشتغل عليها بدل كده].

الهيكل العام | Overall structure:

- Overview

- Opening line about the solution, you must introduce it well refrain from any type of biases with or against it.

جملة افتتاحية عن الحل؛ لازم تقدّمه كويس وتبعد عن أي نوع من التحيز معاه أو ضده.

- Discuss the meta data regarding this solution. (Location, date of completion, goal, and stats regarding its products or byproducts)

اتكلم عن الـ metadata بتاعة الحل ده (المكان، تاريخ التنفيذ، الهدف، وإحصائيات عن الـ products أو الـ byproducts بتاعته).

- Mechanism

- This is the most important division. You must mention—in light details—how the project works or how it was designed.

ده أهم جزء. لازم تذكر، بتفاصيل خفيفة، المشروع بيشغل إزاي أو اتصمم إزاي.

- Discuss how the project makes up for different issues. For example, if it is a recycling site, try and mention how it deals with byproducts or carbon dioxide emissions.

اتكلم إزاي المشروع بيعالج مشاكل مختلفة. مثلاً لو ده موقع recycling، حاول تذكر بيتعامل إزاي مع الـ byproducts أو انبعاثات ثاني أكسيد الكربون.

- Use chronological and process-based writing styles. This section must be simplified for the reader to understand so omit any type of “personality” in your writing and focus on mundane information delivery.

استخدم أسلوب كتابة زمني ومتسلسل حسب الخطوات (chronological and process-based). الجزء ده لازم يكون مبسط عشان القارئ يفهمه، فشيل أي "شخصية" من كتابتك وركّز على توصيل المعلومة بشكل مباشر وعادي.

• Strengths

- In this division, you must mention what makes the project stand out or what part of the project is beneficial. For example, high environmental friendliness or high recycling yield.

في الجزء ده لازم تذكر إيه اللي بيميّز المشروع أو أنهى جزء فيه مفيد. مثلاً إنه صديق للبيئة جداً أو إن الـ recycling yield بتاعه عالي.

- Must not be a subjective opinion, you have to focus on objective statistics and data. Therefore, you can't simply say it looks good or fits its surroundings, however, if mentioned by professionals it is possible. For example, the tower bridge is built in a neo-gothic style to match that of the London Tower. This helps it not stick out and can serve as a tourist attraction, expanding on its function from a simple congestion relief or connection to a sight-seeing spot.

ماينفعش يكون رأي شخصي؛ لازم تركّز على إحصائيات وبيانات موضوعية. يعني ماينفعش تقول ببساطة إن شكله حلو أو ماشي مع المكان اللي حواليه، إلا لو ده كلام متخصصين. مثلاً: "the tower bridge is built in a neo-gothic style to match that of the London Tower. This helps it not stick out and can serve as a tourist attraction, expanding on its function from a simple congestion relief or connection to a sight-seeing spot."

- You must mention at least 3 strengths. You may expand to more than 3 and how it could be beneficial will be discussed forward.

لازم تذكر 3 نقاط قوة على الأقل. ويمكن تزود عن 3، وإزاي ده ممكن يفيدك هنتكلم عنه بعدين.

- **Weaknesses**

- This is the final division; therefore, it must leave a strong impression.

ده آخر جزء، فلازم يسيب انطباع قوي.

- Mention where and how the solution fails to sustain good results. This must also include statistical data and information. For example, you can mention pricing, maintenance costs, low sustainability, percentage of byproducts and environmental impacts (if they are negative impacts of course)

اذكر فين وإزاي الحل بيفشل إنه يحافظ على نتائج كويسة. وده كمان لازم يكون فيه بيانات ومعلومات إحصائية. مثلاً ممكن تذكر السعر، تكاليف الصيانة، ضعف الاستدامة، نسبة الـ byproducts، والآثار البيئية (لو كانت سلبية طبعاً).

- Must also mention 3 points. Expansion is allowed.

لازم برضه تذكر 3 نقاط، ومسموح تزود.

Important Notes: | ملاحظات مهمة

- Solutions don't have to be native to Egypt as long as they solve the problem you mentioned in earlier sections.

الحلول مش لازم تكون من مصر، طالما بتحل المشكلة اللي ذكرتها في الأجزاء اللي فاتت.

- When working on later sections such as the solution and design requirements you will have to keep this section in mind. Meaning that you must strive for your project to have as many strengths and as little weaknesses as possible referring to these prior solutions as reference. For example, if you notice mostly successful solutions were energy efficient and didn't interfere with the environments it is beneficial to have this in your requirements as well. This goes for design and mechanism if it is truly beneficial.

لما تشتغل على الأجزاء اللي بعد كده زي الـ solution and design requirements، لازم تفكر الجزء ده كويس. يعني تسعى إن المشروع بتاعك يكون فيه أكبر عدد من نقاط القوة وأقل عدد من نقاط الضعف، وتستخدم الـ prior solutions دي كمرجع. مثلاً لو لاحظت إن أغلب الحلول الناجحة كانت موفرة في الطاقة ومبتأثرش على البيئة اللي حوالها، يبقى مفيد تحط ده في الـ requirements بتاعتك انت كمان. ونفس الكلام في الـ design والـ mechanism لو كان مفيد فعلاً.

- It is important to include figures in the overview and mechanism divisions to maintain a visual representation and keep the reader's attention

مهم تحط figures في جزئي الـ overview والـ mechanism عشان يبقى فيه تمثيل مرئي وتفضل شادد انتباه القارئ.

- Take genuine inspiration from these prior solutions don't just do it for the portfolio and later sections. Your project doesn't have to be completely original, you can reference other projects, and it strengthens your project if you learn from others and apply with probable scientific reasons backing you up.

خد إلهام حقيقي من الـ prior solutions دي، ماتعملهاش عشان الـ portfolio والأجزاء اللي بعدها وبس. المشروع بتاعك مش لازم يكون أصلي 100%؛ ممكن ترجع لمشاريع تانية، وده بيقوّي مشروعك لو اتعلمت من غيرك وطبقت بأسباب علمية منطقية تسندك.

Solution and Design Requirements

This is the 5th section for you to work on and is quite intuitive and easy.

ده الجزء الخامس اللي تشتغل عليه، وهو سهل ومنطقي.

You start with an overview or a little introduction to make the topic a little natural. In there you mention the importance of setting ground rules and goals in the form of requirements to quantify the projects results and capabilities.

بتبدأ بـ overview أو مقدمة صغيرة عشان تدخل للموضوع بشكل طبيعي. وفيها بتذكر أهمية إنك تحط قواعد وأهداف أساسية في شكل requirements عشان تقيس نتائج المشروع وقدراته بالأرقام.

You have two types of requirements (other than the clear distinction between solution and design ones)

عندك نوعين من الـ requirements (غير الفرق الواضح بين الـ solution requirements والـ design requirements):

1- Mandatory ones mentioned in the Challenge paper.

الإجبارية اللي مذكورة في الـ Challenge paper.

- a. You MUST follow these and make sure your solution satisfies them as it is part of the aspects your project is graded upon. These include weight, length, volume and others specifications

لازم تلتزم بيهما وتتأكد إن الحل بتاعك بيحققها، لأنها جزء من الحاجات اللي مشروعك بيتقيم عليها. ودي بتشمل الوزن والطول والحجم ومواصفات تانية.

- b. Please make the clear distinction between requirements and rules mentioned in the challenge. You will find that some parts mention testing is to be done under supervision and in a specific setting. This isn't a requirement in the design or solution, it is simply a regulation of safety.

لو سمحت فرق بوضوح بين الـ requirements والـ rules المذكورة في الـ challenge. هتلاقي أجزاء بتقول إن الاختبار لازم يتعمل تحت إشراف وفي ظروف معينة؛ ده مش requirement في الـ design أو الـ solution، ده مجرد قاعدة أمان.

2- Optional and strengthening ones

الاختيارية اللي بتقوي المشروع.

- a. These are the requirements you deduce on your own from your research and prior solutions. As much as it may not seem important to have more since they are optional, it is still very important to include new ones to showcase your interest in achieving the best possible results.

دي ال requirements اللي بتستنتجها بنفسك من ال research وال prior solutions. ومع إنها ممكن تبان مش مهمة لأنها اختيارية، بس مهم جداً تضيف منها عشان تبين اهتمامك بالوصول لأحسن نتائج ممكنة.

- b. Don't include ones you aren't going to pursue; if you don't achieve them, remove them.

ماتحطش requirements مش ناوي تنفذها؛ ولو ماحققتهاش، شيلها.

- c. Make it make sense. Don't choose requirements that you achieved that don't make sense or don't add value to the performance of your project like "must have dimensions of x and y length and width" if it doesn't matter and has no impact, don't include it.

خليها منطقية. ماتختارش requirements حقتها بس مالهش معنى أو مابتضيفش قيمة لأداء المشروع، زي "must have dimensions of x and y length and width"؛ لو الأبعاد مش فارقة ومالهش تأثير، ماتحطهاش.

Now differentiating between solution and design requirements doesn't require a lot of effort. Solution requirements are those that should be achieved by ANY solution no matter the type of method of its mechanism, these include sustainability, low maintenance costs, eco friendliness, etc. On the other hand, design requirements are those measurable or descriptive to your prototype specifically, they may also include the materials you think are most viable. This time you can include dimensions, energy production (if it is a power-plant), weight, accuracy, etc.

التفريق بين ال solution requirements وال design requirements مش محتاج مجهود كبير. ال Solution requirements هي اللي لازم يحققها أي حل مهما كان نوعه أو طريقة شغله، زي الاستدامة، وتكاليف الصيانة القليلة، وإنه صديق للبيئة... إلخ. أما ال design requirements فهي اللي بتتقاس أو بتوصف ال prototype بتاعك انت تحديداً، وممكن كمان تشمل الخامات اللي شايف إنها الأنسب. هنا بقى ينفع تحط الأبعاد، إنتاج الطاقة (لو محطة كهرباء)، الوزن، الدقة... إلخ.

To help clear any confusion, here is a couple of examples to help you distinguish between the solution and design requirements (keep in mind the design requirements vary widely between every capstone challenges, those are merely but examples):

وعشان نشيل أي لخبطة، دي كام مثال يساعدوك تفرّق بين الـ solution والـ design requirements (وخلي بالك إن الـ design requirements بتختلف جداً من capstone challenge للتاني، ودي مجرد أمثلة):

solution requirements:

- 1- low costs.
- 2- recyclable.
- 3- Eco friendly.

User-friendly and Safety:

Design requirements:

- 1- **Availability and readiness:** The prototype must be testable, workable, and portable at any time and place.
- 2- **Accuracy and Precision:** The team should provide calculations for accuracy (not exceeding $\pm 5\%$) and precision, either compared to a functional device (or a known standard with relevant scientific references).
- 3- **Volume and Size:** The volume of the prototype should not exceed $0.001m^3$, enhancing the prototype's portability.
- 4- **Fast in producing energy:** The device should, at least, produce **0.04 kWS** within at most five minutes.
- 5- **High strength:** This means the device should be able to withstand harsh conditions, to avoid breaking under workload.

Important notes: | ملاحظات مهمة

- Each requirement must be followed by a few sentences for justification. "low costs, a low-cost solution allows for reproducibility across different financial backgrounds to further increase efficiency in solving the problem at hand"

كل requirement لازم يكون بعده كام جملة تبرّره (justification). مثلاً:

"low costs, a low cost solution allows for reproducibility across different financial backgrounds to further increase efficiency in solving the problem at hand"

- You need to find justification for the mandatory requirements imposed by the challenge. Simply going “this is mentioned in the challenge” is incorrect and will cause you to lose marks.

لازم تلاقي تبرير حتى للـ requirements الإجبارية اللي مفروضة عليك من الـ challenge. إنك تقول بس "this is mentioned in the challenge" غلط وهيخليك تخسر درجات.

- Do NOT mention the solution or mechanism in here at all. All this section is about, is what you hope to achieve. You are answering the “what” but not the “how”

ماتذكرش الـ solution أو الـ mechanism هنا خالص. الجزء ده كله عن اللي انت عايز تحققه؛ انت بتجاوب على "what" مش "how".

- You don't need to mention the specific prior solution that pushed you to pick this section. The simpler and more direct your writing is the better.

مش محتاج تذكر الـ prior solution المعينة اللي خلّتك تختار الـ requirement ده. كل ما كتابتك تبقى أبسط وأوضح، كل ما كان أحسن.

- Figures aren't mandatory and not that helpful anyway.

الـ Figures هنا مش إجبارية ومش مفيدة أوي أصلاً.

- You must include the respective measuring unit for any measurable aspect you mention.

لازم تكتب وحدة القياس المناسبة لأي حاجة بتتقاس بتذكرها.

Selection of solution

Finally, you can discuss the solution you intend to come up with. While there are many debates over whether you should mention 2 solutions and compare them to find the best one, the rubric doesn't actually require this at all; you can immediately speak about the one you chose. Try and be a little specific too, if you think the solution is a power plant, it is mandatory to specify which type of power plant (hydro, aero, or nuclear even)

أخيراً تقدر تتكلم عن الحل اللي ناوي تعمله. وفيه جدل كثير هل المفروض تذكر 2 solutions وتقارن بينهم عشان تختار الأحسن، بس الحقيقة إن الـ rubric مش طالب ده خالص؛ تقدر تتكلم على طول عن الحل اللي اخترته. وحاول تكون محدد شوية؛ يعني لو شايف إن الحل محطة كهرباء، لازم تحدد نوعها إيه (hydro)، aero، أو حتى (nuclear).

Overall structure: | الهيكل العام

• Overview

- Opening line about the solution, you must introduce it well and explain what it is and its role in the community.

جملة افتتاحية عن الحل؛ لازم تقدّمه كويس وتشرح هو إيه ودوره في المجتمع.

- Explain thoroughly how this has the potential to solve the problem to be solved.

اشرح بالتفصيل إزاي الحل ده عنده القدرة إنه يحل الـ problem to be solved.

- Differentiate between the TYPES of the solution without mentioning which one you will stick to.

فرّق بين أنواع الحل ده من غير ما تقول انت هتختار أنهي نوع.

• Mechanism / How it works

- This is the most important division. You must mention how this solution works.

ده أهم جزء. لازم تذكر الحل ده بيشغل إزاي.

- Use chronological and process-based writing styles. This section must be simplified for the reader to understand so omit any type of "personality" in your writing and focus on mundane information delivery.

استخدم أسلوب كتابة زمني ومتسلسل حسب الخطوات. الجزء ده لازم يكون مبسّط عشان القارئ يفهمه، فشيل أي "شخصية" من كتابتك وركّز على توصيل المعلومة بشكل مباشر.

- **Justification / reasoning / strength and weaknesses**

- In this division, you must mention what makes the project stand out or what part of the project is beneficial. For example, high environmental friendliness or high recycling yield.

في الجزء ده لازم تذكر إيه اللي بيميز المشروع أو أنهى جزء فيه مفيد. مثلاً إنه صديق للبيئة جداً أو إن الـ recycling yield بتاعه عالي.

- Give as many reasons as possible that made you choose this solution over other ones.

اذكر أكبر عدد ممكن من الأسباب اللي خلتك تختار الحل ده عن غيره.

- Weaknesses. Try and include little weaknesses or drawbacks you have considered solving/have a solution for in the future. This helps avoid biases and further reinforces the idea of innovation and going about this structurally and scientifically.

Weaknesses (نقاط الضعف): حاول تحط نقاط ضعف أو عيوب صغيرة، تكون فُكِّرت في حلها أو عندك حل ليها في المستقبل. ده بيبعدك عن التحيز، ويبأكد فكرة الابتكار وإنك ماشي في الموضوع بشكل منظم وعلمي.

Important tips: | نصائح مهمة

Keep in mind this is very similar to the Prior Solutions Section and it has pretty much the same structure BUT there are two main clear distinctions to make:

خلي في بالك إن الجزء ده شبه جزء الـ Prior Solutions جداً، وتقريباً ليه نفس الهيكل، لكن فيه فروق واضحة لازم تاخذ بالك منها:

1- No metadata is mentioned during the overview, this is because the solution isn't utilized yet so it wouldn't make sense to have a date, location and outline of construction.

1- مابندكرش أي metadata في الـ overview، لأن الحل لسه ماتنفذش، فمش منطقي يكون ليه تاريخ ومكان وخطوط عريضة للتنفيذ.

2- There should be as little as possible weaknesses and you need to convince the reader that this is the best course of action. Now of course your entire batch will have their own solution with varying designs so to actually convince a reader or the evaluator, give him perspective and a virtue to stick to. For example, your solution may not be the most

efficient but it is very cheap so it makes up for it; this is your selling point which you must inflate among your solution's other strengths.

2- نقاط الضعف لازم تكون أقل ما يمكن، وللازم تقنع القارئ إن ده أحسن طريق. وطبعاً كل الدفعة بتاعتك هيكون عندهم حلول بتصميمات مختلفة، فعشان تقنع القارئ أو المقيم فعلاً، اديله زاوية يبص منها وميزة يمسك فيها. مثلاً ممكن الحل بتاعتك مايكونش الأكفأ، بس رخيص جداً فده بيعوض؛ دي الـ selling point بتاعتك، ولازم تكبرها وتبرزها وسط باقي نقاط قوة الحل.

3- It is strongly advised to mention how this solution meets the solution requirements and has a lot of leeway for modifications and changes if the future demands it. Additionally, try and make it very specific to the problem or Egypt's situation whilst keeping in mind the different communities and their capabilities.

3- منصح جداً إنك تذكر إزاي الحل ده بيحقق الـ solution requirements، وإن فيه مساحة كبيرة للتعديل والتغيير لو المستقبل احتاج ده. وكمان حاول تخليه مخصوص جداً للمشكلة أو لوضع مصر، مع مراعاة المجتمعات المختلفة وإمكانياتها.

Selection of prototype

After you chose the solution in the previous section, you go into more details regarding both the design you chose and the construction.

بعد ما اخترت الحل في الجزء اللي فات، هنا بتدخل في تفاصيل أكثر عن التصميم اللي اخترته وعن التصنيع.

- Choose a specific type and design you intend on prototyping and explain briefly why this type is superior.

اختر نوع وتصميم محدد ناوي تعمله prototype، واطرح باختصار ليه النوع ده أحسن.

- Mention each part of the prototype, what it means, what it does, and its overall importance towards achieving the result or solving the problem. Here are a few examples:

اذكر كل جزء في الـ prototype: يعني إيه، بيعمل إيه، وأهميته في الوصول للنتيجة أو حل المشكلة. ودي كام مثال:

- An insulation layer, this layer is placed midway between each pillar to prevent the outer environment from interacting with the enclosure.
- Low pass filter, utilized to dispose of high frequency extremities and variations due to the power source. The second part of the circuit following the power source and right before the IC
- Battery based 12V power source, helps keep the device portable and delivers the same specifications as an outlet adapter. The beginning and end of the circuit

- If equations are integrated in the system (If is a smart system with a technological interface), include these equations explaining what they calculate and the factors affecting them

لو فيه equations داخله في الـ system (لو هو smart system ليه technological interface)، اكتب الـ equations دي واطرح بتحسب إيه والعوامل اللي بتأثر فيها.

- Mention how these equations are affected by the design and how variations or changes occur as the environment changes.

اذكر إزاي الـ equations دي بتتأثر بالتصميم، وإزاي بيحصل تغيير أو اختلاف لما البيئة تتغير.

- Finally mention how this design and prototype fulfills all the requirements and how it is advantageous

وفي الآخر اذكر إزاي التصميم وال prototype ده بيحققوا كل ال requirements، وإيه مميزاتهم.

Important notes: | ملاحظات مهمة

- While the selection of solution mentions what the project is, the selection of prototype specifies the project's different compartments and how each part exists in harmony with other parts.

ال selection of solution بيقول المشروع إيه، أما ال selection of prototype فيحدد الأجزاء المختلفة للمشروع وإزاي كل جزء متناسق مع الأجزاء الثانية.

- Selection of solution should focus on how this solution fulfills the solution requirements and the selection of prototype should focus on how this specific execution in the design should satisfy the design requirements

ال Selection of solution لازم يركّز على إزاي الحل بيحقق ال solution requirements، وال selection of prototype لازم يركّز على إزاي التنفيذ ده بالذات في التصميم بيحقق ال design requirements.

- You must make a clear distinction between materials you will be using and the parts you need. In design requirements we mention resistance channels, filters and insulation, later you will go over the materials and methods, where you will specify the type of resistance or the values, what material of insulation, filter connection and compartmentalization and so on.

لازم تفرّق بوضوح بين الخامات اللي هتستخدمها والأجزاء اللي محتاجها. في ال design requirements بنذكر resistance channels و filters و insulation، وبعدين في ال materials and methods هتحدد نوع ال resistance أو قيمها، وال insulation من أنهي خامه، وتوصيل ال filter والتقسيم لأجزاء.. (compartmentalization). وهكذا.

- Any future changes to the prototype or design you make due to unexpected events must be denoted here. Don't mention them as changes, just edit this section. For example if you planned on using low pass filters but found high pass filters to be more advantageous to your system, then you must change it in here aswell.

أي تغيير مستقبلي في ال prototype أو التصميم بسبب ظروف مش متوقعة لازم يتسجل هنا. ماتذكرهوش على إنه "تغيير"، عدّل الجزء ده نفسه وخلاص. مثلاً لو كنت مخطط تستخدم low pass filters واكتشفت إن ال high pass filters أفيد لل system بتاعك، لازم تغيّر ها هنا كمان.

Materials & Methods

As the title suggests, Materials and Methods are divided into two parts. The first part is Materials.

In this section, you need to present all the materials used to build your prototype in a **table** with columns including the following for each material:

- Material name — What is it?
- Illustration/Picture — Include a clear picture or illustration of the material.
- Description — Briefly describe the material when necessary.
- Purpose — Explain what the material was used for in your prototype.
- Price — State how much it cost.
- Source — Mention where you obtained it.
- At the end of the table list the total cost of building the prototype

في الجزء ده لازم تعرض كل اللي استخدمتوه في بناء الـ Prototype

و لازم تروسوا الحاجات دي لكل شيء استخدمتوه

اسم المادة: إيه هي المادة دي؟

صورة أو رسم توضيحي: حط صورة أو رسم واضح للمادة.

الوصف: اكتب وصف مختصر للمادة عند الحاجة.

الاستخدام: وضح المادة دي اتستخدمت في إيه في الـ Prototype.

السعر: اذكر سعر المادة.

المصدر: اذكر جيت المادة منين (لو الـ challenge طلب منك كدة

لازم تحدد السعر الأجمالي بتاع المشروع في الآخر

Examples:



Materials

Table 1, illustrates all materials used in constructing the prototype with their usage, source, price

Table 1 Materials List

Material's Name	ATMEGA 328P-U	AUX Input	FTDI Serial Adapter	Capacitors	Op-Amp LM741CN	Crystal oscillator	AUX cable	Common components
Picture								
Usage	Used as the central control unit.	input the sound signals coming from the calibrator through the AUX cable	Allows constant power and simplifies code upload to the processor alongside serial communication	Block DC component of a signal while allowing AC component to pass	Amplify the entering signals to an adjustable voltage,	bypasses the internal clock of the micro-controller to increase its processing speed	transport sound signals from the calibrator to the micro-controller	Completes the circuit
Source	Old Power Supply	Fab Lab	Fab Lab	Old Router	Old Radio	Old Radio	Old speaker	Old Router & Fab Lab
Price	140 EGP "Recycled"	Recycled	130 EGP "Recycled"	8 EGP "Recycled"	5 EGP "Recycled"	4 EGP "Recycled"	18 EGP "Recycled"	67 EGP "Recycled"

Total Cost: 372 L.E

"All written material costs for the quantities used during the project's processing"



MATERIALS



Acrylic & Wood Recycled

Main building materials of the prototype, the wood was used for the base and main structure, while the acrylic was used for covering the structure of the prototype.



Breadboard Reused

A breadboard is a solderless platform to connect everything to.



Fans & Humidifiers Reused

The Fan is used to lower the temperature by replacing hot air with cold air and distributing droplets of the humidifier, while the humidifier adds moisture to the air to regulate humidity.



Peltier Reused

A thermoelectric device that transfers heat from one side to the other when electricity flows, enabling cooling or heating without moving parts



Soil Moisture 40 LE

Measures the water content in soil, helping optimize irrigation, plant health, and environmental monitoring



Arduino-UNO 450 LE

A low-cost, energy-efficient microcontroller, designed for IOT and embedded applications.



DHT-11 50 LE

Used to measure temperature and humidity, providing data in a digital format.



LDR-Module 35 LE

Is a sensor whose electrical resistance decreases as light intensity increases, allowing it to detect and measure brightness



Relays 40 LE x3

A pre-built circuit that includes a relay and control components, allowing the microcontroller to safely turn high-power devices on or off



Water Pump & Hose Reused

Moves water by converting electrical energy into fluid motion

Table 1: Materials used in the construction of the prototype

Total Cost: 695

CHAPTER III.

A. MATERIALS AND METHODS

Table 3.01 – Materials Table.

Item	Description	Usage	Source	Cost	Image
AUX input	An electronic part found in mobile phones and headphones	Used to input the sound signals coming from the calibrator through the AUX cable	Old Mobile Phone	Recycled	
AUX cable	An electronic cable found in headphones and speakers	Used to transport sound signals from the calibrator to the microcontroller	Old Speaker	18 EGP "Recycled"	
10KΩ Resistors	electronic components that limit the flow of electric current	x2 10KΩ Resistor to prevent the reset pin in the microcontroller from randomly activating and used in the op-amp.	Old Radio	0.5 EGP "recycled"	
220 Ω Resistors	electronic components that limit the flow of	220 Ω Resistor used to limit the electric current to prevent	Old Radio	0.5 EGP "Recycled"	

Crystal Oscillator	An electronic circuit that produces a highly stable electrical signal at a specific frequency	Used to bypass the internal clock of the microcontroller to increase its processing speed	Old Router	4 EGP "Recycled"	
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Item	Description	Usage	Source	Cost	Image
LED Lights	A semiconductor device that produces light when an electric current flows through it.	Used to ensure the whole circuit is working, and check if the code is processed	Old Router	0.5 EGP "Recycled"	
Button	a manual switch that breaks an electrical circuit when pressed.	Used to reset the microcontroller's circuit to make it work again from the beginning	Old Router	0.75 EGP "Recycled"	
Breadboard	a reusable platform for building temporary electronic circuits without soldering	Used to build the electronic circuit and connect the microcontroller with the other components	Fab Lab	35 EGP "Recycled"	

	electric current	burning the LED light			
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Item	Description	Usage	Source	Cost	Image
Capacitors	A simple passive device that can store an electrical charge on its plate	x2 10 μF DC coupling capacitors used to block the DC component of a signal while allowing the AC component to pass. x2 0.1 μF for quick discharge, a 2.2 μF, 22 μF, 1 μF cap for signal attenuation, and x2 22 pF caps.	Old Radio	8 EGP "recycled"	
ATMEGA328P	high-performance, low-power Atmel 8-bit AVR RISC-based microcontroller	Used as the central control unit, which optimizes the circuit and computes the signals after it is filtered and amplified	Old Power Supply	140 EGP "Recycled"	

Jumper wires	Electrical wires with connectors at each end, used to connect components in a circuit without soldering	Used to connect the electric components in the circuit with each other	Fab Lab	24 EGP "Recycled"	
Voltage Regulator	Maintains a constant output voltage, regardless of changes in the input voltage	Used To maintain a constant output voltage from the power source	Old Power Supply	5 EGP "Recycled"	
Op-Amp LM741	a high-gain integrated circuit (IC) that amplifies the voltage difference between its two inputs	Used to amplify the entering signals to an adjustable voltage, which the microcontroller can read.	Old Radio	5 EGP "Recycled"	
FTDI Serial Adapter	An adapter module used as a means of data transfer	Used to simplify code upload to the processor alongside serial communications	Fab Lab	130 EGP "Recycled"	

Methods:

The prototype was constructed in multiple stages, and it consists of **two main modules** – the **processor/microcontroller circuit**, and the **AUX amplification circuit**, these two were constructed on two separate **breadboards**. Therefore, there

Methods

The Methods section explains the procedure used to construct, assemble, calibrate, prepare, test, etc. the prototype.

Since this is the portfolio, you must document each and every step used to construct a part of your prototype (for example, don't just say "I made a beam", say "A piece of 50*50 plywood was cut into 20*15 and sanded to have smooth edges")

Organize the Methods into two or more steps/phases.

For each step or phase, explain:

What was done → How it was done → Why it was necessary

For figures, you either include the circuitry of the entire project or the final look. If you don't have enough space for both, the circuitry schematic diagram has a higher priority.

It is also recommended to use figures to show the major steps and development of the prototype throughout the process. So, make sure to document your Capstone project throughout the semester by taking pictures as the prototype is being built and developed. (These figures are included in the presentation rather than the poster itself)

Note that:

Capstone Challenges often have specific requirements for the Methods section, and these requirements may change from one semester to another. Always check the design requirements for your specific challenge.

- 4. Sensor Selection and Calibration:** The system must include **appropriate sensor types** corresponding to the selected parameters. All sensors must be **properly calibrated using standard calibration methods**. **Calibration data, procedures, and calibration curves** must be documented and included in the **Materials and Methods** section of the project poster.

الـMethods بتشرح الخطوات أو الإجراءات اللي اتعملت عشان يتم بناء وتجميع ومعايرة وتجهيز الـPrototype، وغيره حسب طبيعة المشروع.

عشان احنا فالبورثفوليو، المفروض توضح و توثق كل خطوة انت عملتها عشان تعمل حاجة او تبني البروتوتايب بتاعك و تكتب الخطوات، يعني مثلا: متقلش انا عملت عمود/دعامة، قول انا جيت حته خشب خمسين ف خمسين و بعد كده قطعناها عشرين ف خمستاشر و سنفرناها عشان تبقى smooth

قسم الـ**Methods** الي **خطوتين/مرحلتين** او **اكتير**

وفي كل خطوة أو مرحلة، اشرح بالترتيب:

إليه اللي اتعمل → اتعمل إزاي → ليه كان ضروري

بالنسبة لل **Figures** اللي هقولها نصيحة و هو اختياري حاول دايماً توفر مساحة في قسم الـ **Methods** لعرض الشكل النهائي للـ **Prototype** في **figure**

وكمان أنصح إنك تستخدم **Figures** لعرض تطور المشروع و أشكاله المختلفة أثناء عملية بنائه. عشان كده، مهم إنك توثق الـ **Capstone** بتاعك طول الترم عن طريق تصوير الـ **Prototype** أثناء مراحل بنائه وتطوره.

خلي بالك ان الـ **Capstone Challenges** غالباً بيكون ليها متطلبات محددة لازم تتذكر في قسم الـ **Methods**، والمتطلبات دي ممكن تختلف من ترم للتاني زي ما وضحت في ال **example** فوق

عشان كده، اتأكد دايماً من متطلبات الـ **Challenge** بتاعتكم قبل ما تكتب القسم.

Full example of methods:

“*Methods*”

Phase 1: Building the Greenhouse Structure:

A compact greenhouse frame ($\leq 0.25 \text{ m}^2$) was constructed using lightweight, low-cost materials to ensure portability and ease of replication. Transparent plastic covering was used to allow maximum light penetration while maintaining internal environmental conditions. The full assembled prototype is shown in Figure 2.

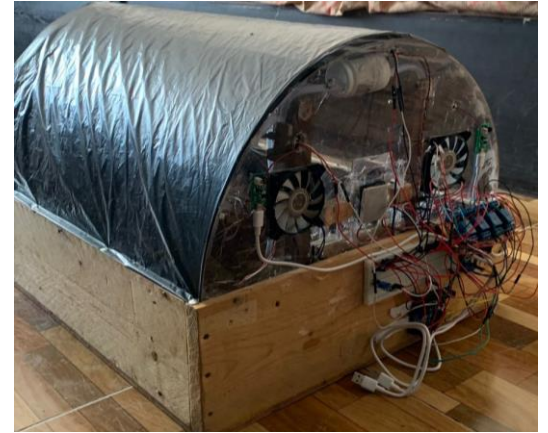


Figure 2: Fully assembled prototype, and circuit.

Phase 2: Installing Water, Air, and Plant Support Systems:

A simple irrigation system was integrated using tubing and a small water pump to regulate soil moisture. Ventilation openings and airflow pathways were added to control humidity and temperature. Plant

holders were positioned to ensure uniform exposure to light and water distribution.

Phase 3: Electronics and Control System:

The system was built around a microcontroller to process sensor data and control actuators. Sensors for temperature, humidity, soil moisture, and light intensity were connected to continuously monitor environmental conditions. Based on sensor readings, the controller activates components such as fans, water pumps, and LED lighting, forming a closed-loop feedback system that maintains optimal conditions automatically.

Phase 4: Calibration of Sensors:

Each sensor was calibrated to ensure accurate readings. Known reference conditions were used to compare expected and measured values, and correction factors were applied where necessary. The calibration results and relationships between sensor output and real values are presented in **Figure 3**.

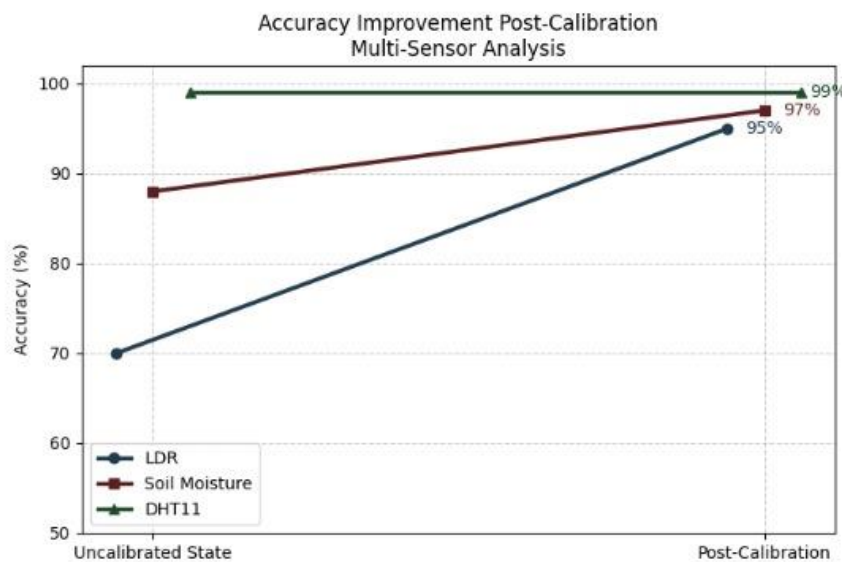


Figure 3: Graph showing the readings of the sensors before and after calibration.

Phase 5: Prepping the Actuators:

Actuators (fan, pump, and LED) were tested individually and then integrated into the system. Trigger thresholds were programmed so that each actuator responds appropriately to environmental changes, ensuring stable and autonomous operation for extended periods.”

The following is an EXTREMELY detailed methods section.

“Methods:

The prototype was constructed in multiple stages, and it consists of **two main modules** – the **processor/microcontroller circuit**, and the **AUX amplification circuit**, these two were constructed on two separate **breadboards**. Therefore, there were **two main building stages**, both of which **required a set of different components**.

One of the main methods we used for recycling is e-waste extraction, where **old devices** were brought and **opened for motherboard extraction**.

For the **mobile phone**, the back was opened and using **very precise screwdrivers**, the screws were removed. After that, the **audio module of the phone was extracted**. This contained the **AUX input**.

For the **old radio**, the chassis was removed by removing screws and the motherboard, the process of extraction here was simple and required a **solder station to free the components**. There were a bunch of **capacitors and resistors** that were extracted from this radio. There was also an **op-amp**, which was used for **audio amplification in the radio**.

For the **old router**, there were a **bunch of LEDs grouped up**, which were removed by a clipper. There was also a **crystal oscillator** which was *easily removed* by using an SMD **heat gun (blows hot air)**. There was also a **button** that was extracted.

For the **old power supply**, there were a bunch of capacitors too, but they were mainly taken from the **old radio**, the most important part of this was the **ATMega328P** and the **voltage regulator** which were extracted using the **heat gun**.

For the **old speaker**, there was a **male-male AUX cable** attached to it **which was taken**.

First Building Stage

1. This stage was the **building stage of the processor**, and this stage required the **ATMega328P** primarily, **there were a bunch of other components used which will be elaborated on**. However, the **ATMega328P** has a limitation of a maximum supply of 5V, this can be easily solvable using the **voltage regulator**.
2. One of the **power rails** was chosen as the output of the **voltage regulator**, this power rail had a $10\mu F$ capacitor placed between its ground and live connections.
3. The **live** and **ground** connections were hooked to the **Output (O/P)** and **GND** in the **voltage regulator**. Specifically, the **voltage regulator** extracted from the **radio**, which was a model 7805 which supplies 5V, this is consistent with the existence of the ATMega328P in the radio.
4. Its **input (I/P)** and **ground (GND)** had a $10\mu F$ capacitor placed between them; these two caps were used for signal noise cancellation. For any wanted input, it has to **pass through the capacitor's V+ and GND row**. **Debug circuitry** was added, which was a **simple LED** connected to **GND** and its anode connected to a **220 Ω resistor** to prevent its *burning*.
5. The **two power rails of the breadboard** were then hooked up together to give a **consistent 5V throughout the board**.
6. The **microcontroller** was then **added to about above the middle of the board** at approximately row 11.
7. A resistor of $10k\Omega$ was hooked between the **live rail** and the **reset pin** of the ATMega328P (as shown in **figure (3.02)**).
8. The **ground rail** was hooked with the **GND pins 8 and 22**.
9. The **live rail** was hooked with the **VCC and AREF pins (7 and 21)**.
10. The **crystal oscillator** was then added between **pins 9 and 10**, two 22 picofarad ceramic capacitors were connected **between GND and the oscillators' pins**.

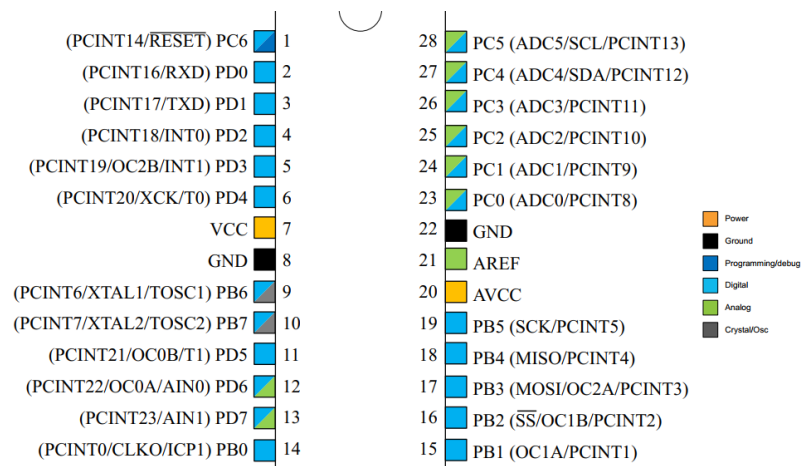
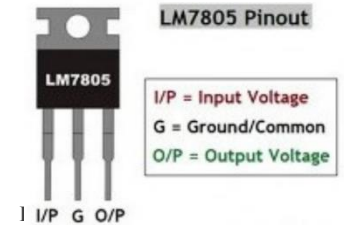


Figure 3.02 – ATMega328P DIP chip diagram.

11. The **reset button** was added above the **microcontroller** as a way to **reset it**, a GND connection was made to one of its **pins** and the **other** was an **output pin** (connection arrangement doesn't matter in buttons.) **connecting to the RESET pin, bypassing the 10k Ω resistor.**

12. The **FTDI** serial adapter was **placed at around the bottom of the breadboard**, the **DTR** pin was connected to a 0.1 μ F capacitor so that it can discharge signals quickly (tells the microcontroller that the device is ready to be received), its output

was connected to the **reset pin**. The **RX** pin which stands for **receive asynchronous data** was connected to the **TX pin of the microcontroller**. The **TX** pin which stands for **transmit asynchronous data** was connected to the **RX pin of the microcontroller**. The **VCC** pin was then hooked onto the **live power rail** and the **GND** was connected to the **ground connection**.

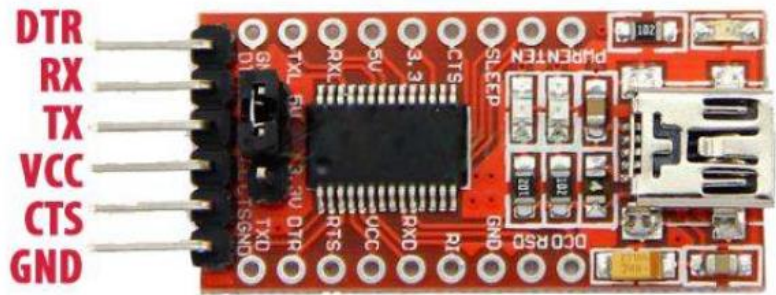


Figure 3.03 – a diagram showing the pins of an FTDI adapter.

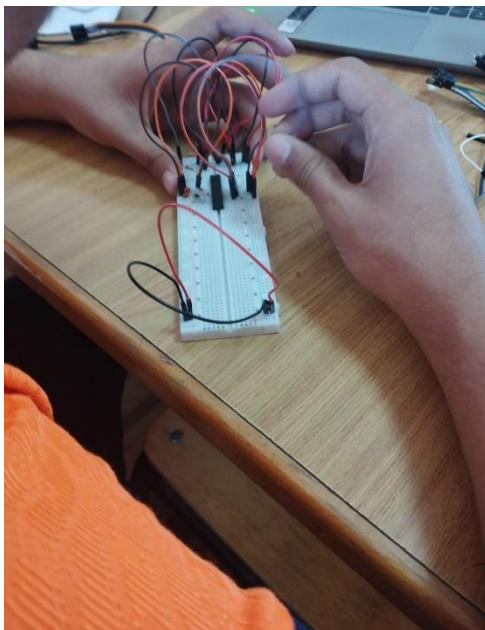


Figure 3.04 – the initial construction of the prototype.

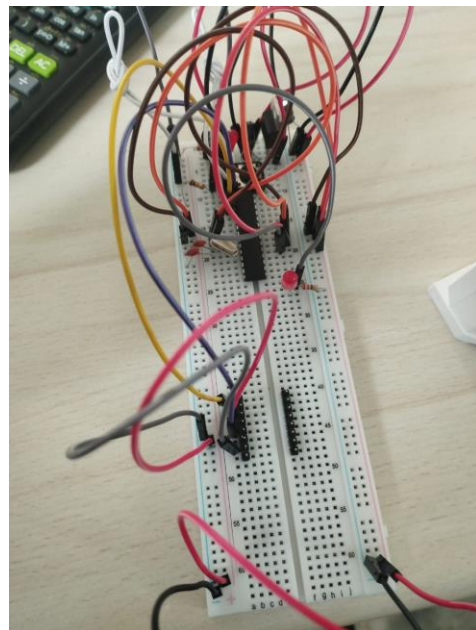


Figure 3.05 – a later stage of the construction after the ATmega328P had been installed.

Second Building Stage

1. This stage was the **building stage of the amplifier**, it relied on the **LM741** primarily, this is the **op-amp** that the circuit is **going to use**.
2. **Figure (3.06)** describes the **pins of the IC**; the OFFSET NULL and NC pins can be ignored. The most important parts of this are mainly the **inverting input**, **non-inverting input**, V^- , V^+ , and the output.
3. The **prototype was determined to be an AC-coupled, biased, non-inverting amplifier with a negative feedback configuration**. Meaning that the positive input must pass through an AC-coupling stage before reaching the non-inverting input. The same AC-coupling must be done for ground before reaching the inverting input.
4. Another **breadboard** was attached to the **main processing breadboard**; this is so a clean slate may be prototyped on.
5. The **AUX** input whose GROUND and LEFT CHANNEL are soldered with a male-to-male jumper wire as shown in **figure (3.07)**.
6. These jumpers are connected to the **power rail of the second breadboard**, where the **ground** is connected to the **ground rail** and the **left channel** is connected to the **live rail**. A capacitor of $1\mu F$ then pulls **from the ground rail** into a $10k\Omega$ resistor.
7. The **resistor** is then **connected to the same pin as the inverting input**.
8. A resistance of $100k\Omega$ is wired in **parallel** with the **inverting input**. This is for the **negative feedback**. This gives a gain of $G = 1 + \frac{R_f}{R_i}$ where R_f is the $100k\Omega$ resistance and R_i is the $10k\Omega$ resistance.
9. The **live rail of the processing board** is connected to an arbitrary, empty row in the **amplification board**. **Call this the live row**.
10. The **ground rail of the processing board** is connected to an arbitrary, empty row in the **amplification board**. **Call this the ground row**.
11. A capacitor of $2.2\mu F$ is **wired from the live rail of the amplification board** to the **input of a voltage divider row**.
12. Two resistors of $10k\Omega$ are **wired in parallel**, one of them connecting to the **ground row** and the other connecting to the **live row**, all summing up into the **biased row**

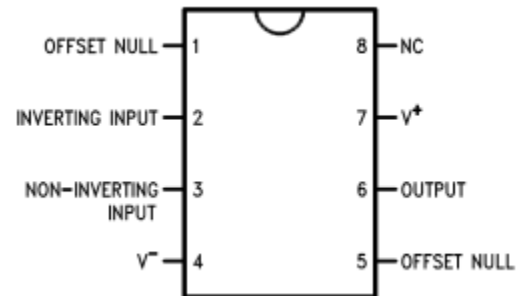


Figure 3.06 – a diagram showing the pins of an LM741 op-amp



Figure 3.07 – an AUX input chip.

(as in, the input signal is now biased after it was input from the capacitor and biased by the voltage dividers).

13. The **biased row** is then **connected to the non-inverting** input.
14. For V^- and V^+ , **two batteries** are required for **dual-supply voltage**. These two batteries **are 9V** and through **grounding (connecting them to the ground row)**, can turn into +9V and -9V. These can then be **wired to their respective pins**.
15. The **output** is taken, and an *arbitrary, empty row* is chosen for **filtering** by using a high-pass filter. This **HPF** has a capacitor of $22\mu F$ and a resistor of 300Ω , filtering an approximate $21Hz$.
16. The **output from the HPF** is then taken by a jumper to the **A0 pin in the microcontroller, otherwise known as pin 23**.

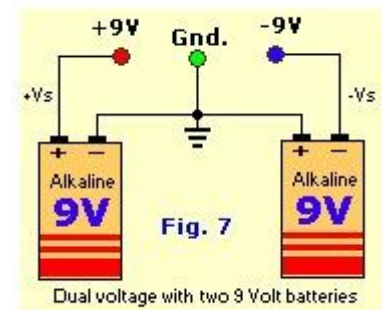


Figure 3.08 – a dual-supply voltage created by two 9V batteries.

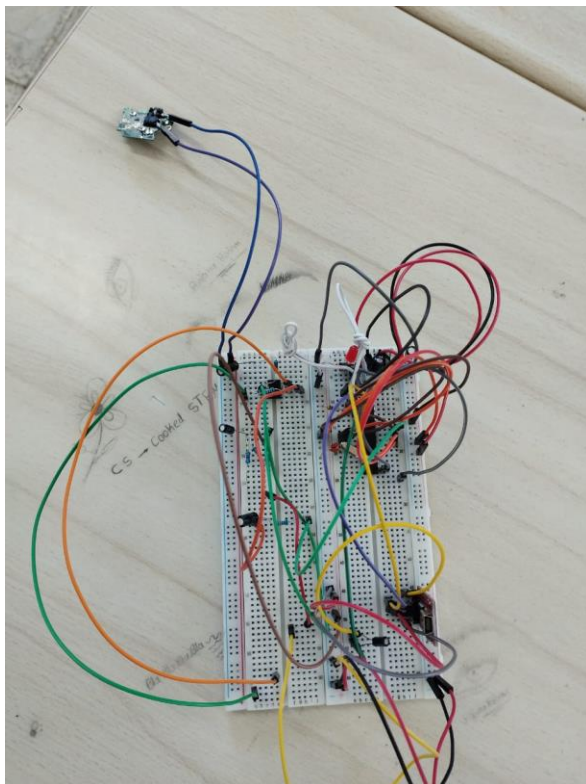


Figure 3.09 – an image of the fully constructed prototype.

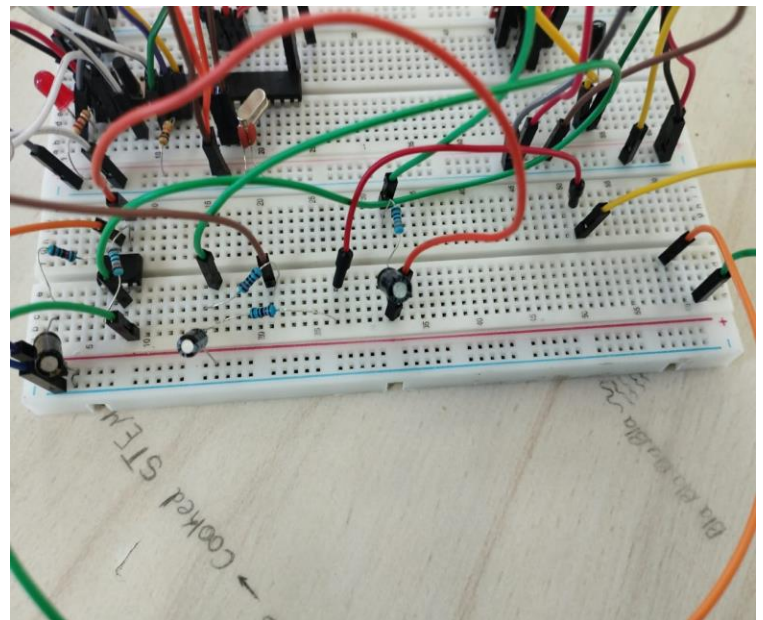


Figure 3.10 – ditto, from another angle.

Any variable thereafter is **calculated** using the **processor**, this can be then related to the “*arduinoFFT*” library used in the code. However, there are a **few things to be noticed when dealing with this library and configuration, of which are:**

1. The **offset frequency** the program gives when nothing is connected at all – this is technically a **systematic error**, and this error is **consistent throughout readings**, therefore, this *must* be subtracted from the **output frequency through the application**.
2. The **biasing voltage is 2.5V**, meaning that when performing an *analogRead()* function and converting it to a **voltage value**, meaning that 2.5 must be subtracted from the **reading**.
3. The **program uses a windowing function**, and its parameters are the usage of a **hamming window**; this is used to **decrease noise and increase accuracy**.
4. Any **complex wave that outputs because of a complex Fast Fourier Transformation** must be **converted to its magnitude** using the *complexToMagnitude(...)* function. (See the *arduinoFFT* GitHub for more precise information or function input parameters.)
5. Two functions *may be utilized*, either a function you write by your own to achieve a **dominant frequency** or the built-in *majorPeak()* function, which *returns (gives)* the **dominant frequency**. (Don't forget to subtract the offset frequency (systematic error))

```
1 #include <arduinoFFT.h>
2
3 //FFT definitions
4 #define SAMPLES 128 // arduinoFFT library requires this to be two squared to any number (2^n).
5 #define SAMPLING_FREQUENCY 4000 // Hz (Nyquist: max detectable frequency = SAMPLING_FREQUENCY/2) || in a perfect ADC config, it can read up to 10kHz, meaning that this freq. can maxima
6
7 //pin definition and references
8 #define AUDIO_IN_PIN A0 // Analog input pin
9 #define REF_VOLTAGE 2.5 // Reference voltage for op-amp output
10 #define ADC_REFERENCE 5.0 //ATMega328 ADC reference voltage
11
12 // Variables for sleep time (during the sampling loop)
13 unsigned int sampling_period_us;
14 unsigned long microseconds;
15
16 //There exists a systematic error caused by the library's configurations, we can call the constant frequency the "ground frequency"
17 const float ground_frequency = 31.2;
18
19 // The arrays (otherwise known as vectors) in which our data will be stored (real signal gets decomposed into its constituent signals.)
20 float vReal[SAMPLES];
21 float vImag[SAMPLES];
22
23 // Initialize the library for usage
24 ArduinoFFT<float> FFT = ArduinoFFT<float>(vReal, vImag, SAMPLES, SAMPLING_FREQUENCY, true);
```

Figure 3.11 – first part of the code (variables and definitions)

Figure (3.11) is the set of all **variables** required for **initialization**.

```

26 void setup() {
27   /*
28   A high baud rate is required for a lot of fluctuations or changes per second, this is better for a highly accurate/fast reading by collecting samples closely packed
29   so that it may be processed in a semi-real-time manner; however, this is not completely in real-time, especially due to the fact that the sampling frequency limits
30   this at a certain limit.
31   */
32   Serial.begin(115200);
33
34   // a constant given in microseconds for the sleep time
35   sampling_period_us = round(1000000 * (1.0 / SAMPLING_FREQUENCY));
36
37   // Configure ADC reference if needed (for 5V Arduinos)
38   //analogReference(DEFAULT); // Use 5V reference for ADC
39   Serial.print("Sampling Frequency: ");
40   Serial.print(SAMPLING_FREQUENCY);
41   Serial.println(" Hz");
42   Serial.print("Max Detectable Frequency: ");
43   Serial.print(SAMPLING_FREQUENCY / 2);
44   Serial.println(" Hz");
45   Serial.println("Waiting for loop initialization\n");
46 }

```

Figure 3.12 – second part of the code (setup and initialization).

Figure (3.12) is the initialization of everything before the readings start occurring.

```

48 void loop() {
49   // collect enough samples for processing
50   for (int i = 0; i < SAMPLES; i++) {
51     microseconds = micros(); // Start timing
52
53     // Read analog value and convert to voltage with 2.5V reference
54     int adcValue = analogRead(AUDIO_IN_PIN);
55     float voltage = ((adcValue * ADC_REFERENCE) / 1024.0) - REF_VOLTAGE;
56
57     // Store in real part (imaginary part is zero for time domain, meaning that the input wave is completely real)
58     vReal[i] = voltage;
59     vImag[i] = 0.0;
60
61     // Wait until next sample time
62     while (micros() < (microseconds + sampling_period_us)) {
63       // Busy wait for precise timing
64     }
65   }
66
67   // Perform FFT
68   // This is a windowing function to decrease noise and spectral leakage
69   FFT.windowing(vReal, SAMPLES, FFTWindow::Hamming, FFTDirection::Forward);
70   // Compute the FFT - this fills the variables vReal and vImag with their corresponding variables
71   FFT.compute(vReal, vImag, SAMPLES, FFTDirection::Forward);
72   // Converts complex amplitudes into a readable frequency reading in the frequency-time domain - this overwrites the first half of the real data array
73   // As FFT performs a splitting into two arrays of half the size, the vImag array is merged into the original vReal array. Meaning that for the first N_samples/2 it's the imaginary
74   // weighted data, meanwhile, the second sample size is the real data.
75   FFT.complexToMagnitude(vReal, vImag, SAMPLES);
76
77   // Find dominant frequency - subtract from ground frequency due to a systematic error
78   float peakFrequency = findDominantFrequency() - ground_frequency;
79
80   // Display results
81   if (peakFrequency > 0) {
82     Serial.print("Detected Frequency: ");

```

Figure 3.13 – half of the repeated code snippet, the function that recalculates frequency periodically.

```

80 // Display results
81 if (peakFrequency > 0) {
82     Serial.print("Detected Frequency: ");
83     Serial.print(peakFrequency, 1);
84     Serial.println(" Hz");
85 }
86 else if (peakFrequency < 0){
87     Serial.println("[[ERROR]]: NEGATIVE FREQUENCY");
88 }
89
90 // Small delay before next measurement
91 delay(500);
92 }

```

Figure 3.14 – the other half of the loop.

Figure (3.13) & Figure (3.14) represent the loop function, where every reading occurs.

```

94 float findDominantFrequency() {
95     float peak = 0;
96     unsigned int peakIndex = 0;
97
98     // Find the peak magnitude (skip DC component at index 0)
99     for (int i = 1; i < (SAMPLES / 2); i++) {
100         if (vReal[i] > peak) {
101             peak = vReal[i];
102             peakIndex = i;
103         }
104     }
105
106     // Calculate frequency from bin index
107     float frequency = (peakIndex * 1.0 * SAMPLING_FREQUENCY) / SAMPLES;
108
109     // Only return if signal is above noise threshold
110     if (peak > 0.1) { // Adjust threshold as needed
111         return frequency;
112     }
113
114     return 0;
115 }

```

Figure 3.15 – a function used to calculate the most dominant frequency out of all the complex waves given.

Figure (3.15) represents the findDominantFrequency function required for identifying the frequency.”

Test Plan

This is one of the most important sections in your portfolio. Most grading teachers will focus on this part along with your analysis to make sure you followed the procedures as you mentioned. That's why it is important to be as concise as possible when writing the test plan and you have to focus on the details of each step.

ده من أهم الأجزاء في الـ portfolio بتاعك. أغلب المدرسين اللي بيصححوا بيركزوا على الجزء ده مع الـ analysis، عشان يتأكدوا إنك مشيت على الخطوات زي ما قلت. عشان كده مهم تكون دقيق ومختصر جداً وانت بتكتب الـ test plan، وتركز على تفاصيل كل خطوة.

- The test plan must only include quantifiable data or measurements that you plan on taking.

الـ test plan لازم يكون فيه بس داتا أو قياسات بالأرقام (quantifiable) ناوي تاخدها.

- Any subjective criteria you want to test must be evaluated using a scientific method based on the results of an anonymous survey. For example requirements like user friendliness and easy operation can be evaluated by having anonymous users try the project or its interface and fill a survey afterwards detailing their experience.

أي معيار ذاتي (subjective) عايز تختبره لازم يتقيم بطريقة علمية مبنية على نتائج anonymous survey. مثلاً requirements زي user friendliness و easy operation ممكن تتقيم إنك تخلي مستخدمين مجهولين يجربوا المشروع أو الـ interface بتاعه، وبعدين يملوا survey يوصفوا فيه تجربتهم.

- Each step must be mentioned in detail and contain the following:

كل خطوة لازم تتذكر بالتفصيل ويكون فيها الآتي:

- Process and setup (including safety procedures) [mandatory]

العملية نفسها والحاجات اللي انت جاييها عشان تعمل الـ test plan (وده يشمل إجراءات الأمان) [إجباري].

- Step importance and role [mandatory]

أهمية الخطوة ودورها [إجباري].

- Possible variations [optional]

الاختلافات المحتملة [اختياري].

- Pass criteria / which design requirement to satisfy

الـ Pass criteria، يعني الخطوة دي بتحقق أنهي design requirement.

- You must mention how your team plans on calculating the error and accuracy of the prototype and how you plan on dealing with it if you deem it necessary.

لازم تذكر التيم ناوي يحسب الـ error والـ accuracy بتوع الـ prototype إزاي، وهيتعامل معاهم إزاي لو شاف إن ده ضروري.

- There must be NO mention of the real results in the test plan section.*

ماينفعش تذكر النتائج الحقيقية خالص في جزء الـ test plan.

For example, a fulfilling test plan would be as such: | مثال

“Since a lot of requirements are of quantifiable data, it is essential for the prototype to be tested along a concise plan to figure out whether it is successful or it needs new modifications to push it towards that efficiency needed.

To make sure the design is reliable for humidity measurement, a fixed and predetermined range of humidities is created as the reference and base of the needed calculations. The procedure is as follows:

- 1- Safety coats, gloves and goggles are needed as interaction with abrasive and potentially dangerous chemicals is in effect.
- 2- Preparation of each solution with specific molar concentrations. A solution of 2M NaCl which yields X RH {percent humidity, the measuring unit of humidity}, a solution of 0.5M MgCl which yields a Y RH, and finally a solution of 1M LiCl which yields a Z RH are all prepared in advance; this is because RH values need time to saturate their normal yield.
- 3- Solutions will be kept at room temperature as that is the respective temperature to the predetermined RH values. This makes sure no fluctuations occur.
- 4- To avoid any humidity leakage when utilizing the device, it must be inserted and kept for a time of X hours to make sure the humidity re-saturates.
- 5- At the end of the time period, the readings from the last Y minutes are averaged together. This new value will be used in calculating the accuracy and error percentage through the equation; $\text{measure average/true value} * 100\% = \text{error\%}$.
- 6- If the error% across all 3 trials is less than or equal to 5%, it passes the predetermined requirement of accuracy, deeming the device successful and accurate. However, if the error is higher than anticipated, a few modifications to the potentiometer and sensitivity of the sensors must be made with new documented testing until the preferred result is achieved.
- 7- After proper testing is completed, solutions are disposed of safely by.....”

The test plan itself is conducted with tools, these tools must be verified school equipment, said equipment must be shown in any pictures taken during construction to verify that capstone construction was done on school grounds. This a really simple section, but you'll also need to attach the methodology you're going to use your tools for. For example, if you're going to use a "function generator," you're going to want to explain *how* you're going to use it in actual application. The "function generator" for example: "is going to be turned on and calibrated to 1250Hz so that the prototype can get hooked up to it to get tested." The mechanism of the function generator can be written about in the "Research" section. If you're using tools like a handsaw or a screwdriver or whatever else for testing, then list EVERYTHING used for the test plan in terms of tools here.

الـ test plan نفسه بيتعمل بأدوات، والأدوات دي لازم تكون أجهزة مدرسة معتمدة، ولازم تبان في أي صور بتتصور أثناء التصنيع عشان تثبت إن الـ capstone اتعمل جوه المدرسة. ده جزء بسيط جداً، بس هتحتاج كمان تكتب الطريقة اللي هتستخدم بيها الأدوات دي. مثلاً لو هتستخدم "function generator"، لازم تشرح *إزاي* هتستخدمه في التطبيق الفعلي. الـ "function generator" مثلاً: "is going to be turned on and calibrated to 1250Hz so that the prototype can get hooked up to it to get tested." الـ function generator نفسه فممكن تكتبها في جزء الـ "Research". ولو بتستخدم أدوات زي منشار يدوي أو مفك أو أي حاجة تانية في التجارب بناعتك، اكتب كل الأدوات المستخدمة في الـ test plan هنا.

Data Collection

Data collection relies on the test plan and any simulations, tests, or models you've ran. This also includes any measurements you've taken. This section should be (preferably so) filled out as you write your entire portfolio. Data from research papers should be implemented here and your research section so you can have a reference and a storage for when you want to go back for any data you've collected throughout the entire semester regarding the prototype.

الـ Data collection يعتمد على الـ test plan وأي simulations أو tests أو models عملتها، وكمان أي قياسات أخذتها. والأفضل إن الجزء ده يتملى أول بأول وانت بتكتب الـ portfolio كله. والداتا اللي من الـ research papers تتحط هنا وفي جزء الـ research، عشان يبقى عندك مرجع ومخزن ترجعه لأي داتا جمعتها طول الترم عن الـ prototype.

An example of data collection is to record length values for something and getting their average value later:

مثال على الـ data collection: إنك تسجل قيم أطوال لحاجة معينة وبعدين تطلع متوسطها:

The 15cm length is the real length provided in the design requirements, but as well known, errors tend to happen and the values should never be that perfect, for example: When measuring the cut down parts, the measured values were as follows:

Real value	Measured value
15cm	15.1cm
15cm	14.9cm
15cm	15.4cm
15cm	14.7cm
15cm	15cm
15cm	14.9cm
15cm	15.1cm

The average measured value was 14.97857143cm which is approximately equal to 15cm, to get the absolute error we must subtract the average measured value to get 0.02cm as the absolute error, the

NOTE: The average measured value should be written according to significant figure rules and should also be rounded off if needed, unlike the previous example, the number should be rounded up by decimals first.

ملحوظة: متوسط القيمة المقاسة لازم يكتب حسب قواعد significant figures، ويتقرَّب لو محتاج. وعلى عكس المثال اللي فات، الرقم لازم يتقرَّب بالكسور العشرية الأول.

For the structure itself, engineers use a thumb rule to determine the truss height, which is that the height of the truss is usually the 1/10 of the span length, which was 98.75/10 which basically rounds to 10cms along the vertical axis (Y-Axis). The height should also

be rectangular and not in the shape of a square to have a better weight distribution, the following two tables represent how having the truss frame as a rectangle has better force distribution on it than the frame as a square: in figure 15 (frame as a square), you can see that the force is almost null on all truss pieces except very few that have high amounts of forces almost reaching 0.53 units (minimized ratio) in the compression force, on the right in figure 16 (frame as a rectangle), you can see that it has better results where the maximum unit it reached was 0.46 in the compression

Figure 15, frame as a square.

	Compression Force/Strength	Tension Force/Strength
97	0.18	0.00
97	0.00	0.14
97	0.00	0.28
97	0.00	0.31
97	0.00	0.19
97	0.00	0.00
97	0.00	0.13
49	0.08	0.00
49	0.36	0.00
49	0.00	0.11
49	0.08	0.02
66	0.53	0.00
66	0.00	0.26
66	0.37	0.00
66	0.00	0.18
97	0.21	0.00
97	0.45	0.00
97	0.50	0.00
97	0.29	0.00
97	0.00	0.03
49	0.00	0.08
49	0.03	0.05
49	0.00	0.06
49	0.01	0.08
49	0.00	0.09
49	0.05	0.04
49	0.02	0.00
49	0.26	0.00
31	0.00	0.03
31	0.00	0.14
66	0.21	0.00
66	0.00	0.11
66	0.11	0.03
66	0.05	0.06
66	0.27	0.00
66	0.00	0.14
66	0.43	0.00
66	0.00	0.21
97	0.00	0.07

	Compression Force/Strength	Tension Force/Strength
44	0.00	0.07
97	0.00	0.06
97	0.19	0.00
97	0.35	0.00
97	0.37	0.00
97	0.23	0.00
97	0.00	0.00
44	0.00	0.01
97	0.00	0.00
97	0.00	0.13
97	0.00	0.21
97	0.00	0.20
97	0.00	0.11
97	0.10	0.00
46	0.00	0.07
23	0.07	0.00
23	0.39	0.00
72	0.46	0.00
72	0.00	0.19
23	0.00	0.11
23	0.09	0.02
72	0.32	0.00
72	0.00	0.14
23	0.00	0.08
23	0.04	0.05
72	0.18	0.00
72	0.00	0.08
23	0.00	0.06
23	0.01	0.07
23	0.00	0.10
23	0.06	0.04
23	0.01	0.00
23	0.29	0.00
72	0.11	0.02
72	0.04	0.04
72	0.25	0.00
72	0.00	0.10
72	0.39	0.00
72	0.00	0.16

Figure 16, frame as a rectangle

An example ^ (This was written in the research section, which is incorrect, the tables on the left and right should've been written and described in the data collection section and referenced by hyperlink in the research section.)

مثال ^ (المثال ده اتكتب في جزء الـ research، وده غلط؛ الجداول اللي على الشمال واليمين كان المفروض تتكتب وتتوصف في جزء الـ data collection، ويتعملها reference بـ hyperlink في جزء الـ research).

You're also going to write the results of your test plan in this section, which should look like the following:

وهتكتب كمان نتائج الـ test plan في الجزء ده، والمفروض تبقى شبه اللي عالمين:

This signified the importance of the FFT process regarding the breakdown of the complex waveform into a simpler sinusoidal wave whose

frequency, amplitude, and function are given and graphed. The following table is the list of a few readings given against a calibration frequency. This was done by hooking the AUX input of the phone to the amplification circuit and performing an analysis.

Table 3.02 – Frequency Data Table.

Trials	Calibrated frequency (Hz)	Measured frequency (Hz)	Difference	Relative error
1 st Trial	850.0 Hz	843.7 Hz	6.3	0.7%
2 nd Trial	900.0 Hz	906.2 Hz	6.2	0.7%
3 rd Trial	950.0 Hz	937.5 Hz	12.5	1.3%
4 th Trial	1000.0 Hz	1000.0 Hz	0.0	0.0%
5 th Trial	1050.0 Hz	1062.5 Hz	12.5	1.2%
6 th Trial	1100.0 Hz	1093.8 Hz	6.2	0.6%
7 th Trial	1150.0 Hz	1156.3 Hz	6.3	0.6%
8 th Trial	1200.0 Hz	1218.8 Hz	18.8	1.6%
9 th Trial	1250.0 Hz	1250.0 Hz	0.0	0.0%
10 th Trial	1300.0 Hz	1312.5 Hz	12.5	1.0%
11 th Trial	1350.0 Hz	1343.8 Hz	6.2	0.5%
12 th Trial	1400.0 Hz	1406.3 Hz	6.3	0.5%
13 th Trial	1450.0 Hz	1468.8 Hz	18.8	1.3%
14 th Trial	1500.0 Hz	1500.0 Hz	0.0	0.0%

15 th Trial	1550.0 Hz	1562.5 Hz	12.5	0.8%
16 th Trial	1600.0 Hz	1625.0 Hz	25.0	1.6%
17 th Trial	1650.0 Hz	1656.3 Hz	6.3	0.4%
18 th Trial	1700.0 Hz	1718.8 Hz	18.8	1.1%
19 th Trial	1750.0 Hz	1750.0 Hz	0.0	0.0%
20 th Trial	1800.0 Hz	1812.5 Hz	12.5	0.7%
21 st Trial	1850.0 Hz	1875.0 Hz	25.0	1.4%
22 nd Trial	1900.0 Hz	1906.3 Hz	6.3	0.3%
23 rd Trial	1950.0 Hz	1937.5 Hz	12.5	0.6%
Average	-	-	-	0.7%

This is also the place where you write your results, similarly to how you write them in the poster, you'll write them here. You're going to note down your positive and negative results as well as what they may imply for other people attempting to recreate this, you're also going to write redundancies or discrepancies in your results (honesty is better than lying and failing to do so.)

وده كمان المكان اللي بتكتب فيه النتائج، بنفس الطريقة اللي بتكتبها بيها في الـ poster. هتسجل النتائج الإيجابية والسلبية، وإيه معناها اللي هيحاول يعيد عمل المشروع ده، وكمان هتكتب أي تكرار أو تناقض (discrepancies) في نتايجك (الصراحة أحسن من إنك تكذب وتقع).

The Results section presents the outcomes obtained from testing the prototype. It should show whether the prototype actually met its Design Requirements and what problems were discovered during testing.

جزء الـ Results بيعرض النتائج اللي طلعت من اختبار الـ prototype، ول لازم يوضح هل الـ prototype حقق الـ Design Requirements فعلاً ولا لا، وإيه المشاكل اللي ظهرت أثناء الاختبار.

The Results should include both positive and negative results, preferably in separate sections. It is also recommended to mention the changes or modifications made to address the negative results.

الـ Results لازم يكون فيها النتائج الإيجابية والسلبية، ويُفضّل كل واحدة في جزء لوحدها. ومنصوح كمان إنك تذكر التغييرات أو التعديلات اللي عملتها عشان تعالج النتائج السلبية (ده لو انت حلتها).

For each major result, whether positive or negative, explain:

لكل نتيجة مهمة، سواء إيجابية أو سلبية، اشرح:

What was observed → What the result showed → Why the result matters

For example, instead of simply saying: | مثال

"The pump worked."

Give the actual result and what it demonstrated: | الصحيح

"The pump increased soil moisture from 58% to 81% in 47 seconds, demonstrating that the irrigation actuator could respond effectively when the soil moisture fell below the required range."

Figures: | الأشكال

It is important to support your numbers and test results with Tables and Graphs whenever appropriate. These should clearly present the data obtained during testing.

مهم تدعم أرقامك ونتائج الاختبار بـ Tables و Graphs كل ما يكون ده مناسب، ويكونوا عارضين الداتا اللي طلعت من الاختبار بشكل واضح.

Note: | ملحوظة

The Results section should focus on actual observations and measurements, rather than detailed explanations of why the results happened.

جزء الـ Results لازم يركّز على الملاحظات والقياسات الفعلية، مش على شرح مفصّل لليه النتائج طلعت كده.

Detailed interpretation and explanations of the results belong primarily in the Analysis section.

التفسير والشرح المفصّل للنتائج مكانه الأساسي جزء الـ Analysis.

More examples: | أمثلة تانية

waveform into a simpler sinusoidal wave whose frequency, amplitude, and function are given and graphed. The following table is the list of a few readings given against a calibration frequency. This was done by hooking the AUX input of the phone to the amplification circuit and performing an analysis.

Table 2 – Frequency Data Table.

Trials	Calibrated frequency (Hz)	Measured frequency (Hz)	Difference	Relative error
2 nd Trial	900.0 Hz	906.2 Hz	6.2	0.7%
4 th Trial	1000.0 Hz	1000.0 Hz	0.0	0.0%
15 th Trial	1550.0 Hz	1562.5 Hz	12.5	0.8%
16 th Trial	1600.0 Hz	1625.0 Hz	25.0	1.6%
17 th Trial	1650.0 Hz	1656.3 Hz	6.3	0.4%
Average	-	-	-	0.7%

Positive results: 1. The prototype matched the design requirements, and the relative error was less than 5% by 4.3%, (relative error = 0.7%) 2. The amplitudes that the device displayed were like the amplitude produced by the function generator. 3. Moreover, the high-pass filter fully blocked the noise at the second, third, fourth trials. 4. The microcontroller applied the algorithm of the Cooley-Tukey FFT successfully with minimal time loss and full code optimization, running at a speed of $O(n \log n)$. 5. The program was able to accurately replicate the major part of the frequency domain, where a frequency f may have the maximum amplitude, signifying the two essential variables required to recreate the sine wave according to the function: $\omega(t) = \text{Amplitude} \cdot (\sin(2\pi ft) + \cos(2\pi ft))$. This wave is fed a series of inputs equal to the number of samples to be taken, and the variable t for each point is calculated as $n/\text{SAMPLING_FREQUENCY}$ (where $n \leq 128$).

Negative results: 1. The laptop charger caused a severe inaccuracy in the reading because it caused severe interference with the ADC meaning that no reading was accurate. 2. The high-pass filter failed to remove all the noise from the signal as there were some amplitudes (cancelled out by the windowing function). 3. There was a systematic error in the form of an offset equal to 31.2Hz caused because of the FFT library. 4. The limitation of the accuracy by the number of samples to 128 samples. 5. Limiting the maximum detectable frequency.

Analysis and Discussion

The analysis and discussion section is practically the core of your capstone project for both the portfolio and poster. Its only legitimate challenge is its limited space (in the poster) and intense need for conciseness and focus. A lot of people, including evaluators and teachers, may not be the best informed and knowledgeable about the project and its scientific basis, no matter how simple it is. That's why we follow the principle of "explain it to me like I'm five years old" fulfilling this principle deems your analysis to be thorough and understandable without the need for a scientific background of any kind.

جزء الـ analysis and discussion هو عملياً قلب الـ capstone project، في الـ portfolio والـ poster الاتنين. والتحدي الحقيقي الوحيد فيه هو المساحة المحدودة (في الـ poster) والاحتياج الشديد للاختصار والتركيز. ناس كتير، منهم المقيمين والمدرسين، ممكن مايكونوش ملّمين بالمشروع وأساسه العلمي مهما كان بسيط. عشان كده بنمشي على مبدأ "explain it to me like I'm five years old" (اشرحها لي كأني طفل عنده 5 سنين)، ولما تحقق المبدأ ده يبقى الـ analysis بتاعك شامل ومفهوم من غير ما القارئ يحتاج أي خلفية علمية.

First lets start off with what you should go over in this section before we get to how and all the specifics:

خلينا نبدأ الأول باللي المفروض نتكلم عنه في الجزء ده، قبل ما ندخل في الـ "إزاي" والتفاصيل:

- Introductory phase. In here you start by mentioning the grand challenges and problem to be solved that urged you to work on your project.

الـ **Introductory phase** (مرحلة التمهيد): هنا بتبدأ بذكر الـ grand challenges والـ problem to be solved اللي خلوك تشتغل على المشروع.

- Ground preparation phase. In here you follow up with the project you have chosen and how it is believed to have a positive impact on the aforementioned issues you want to overcome.

الـ **Ground preparation phase** (مرحلة تجهيز الأرضية): هنا بتكمل بالمشروع اللي اخترته، وإزاي متوقع إن يكون فيه تأثير إيجابي على المشاكل اللي ذكرتها وعمايز تتغلب عليها.

- The introductory phase as well as the ground preparation phase could technically go as "summarizations" for both chapter 1 and 2 respectively.

الـ introductory phase والـ ground preparation phase ممكن يعتبروا عملياً "ملخصات" لـ chapter 1 و chapter 2 بالترتيب.

- The Discussion phase. In here you discuss how the projects parts exist in unison and harmony, where you mention their role, effect, and how they function. This is mentioned in a manner to simply explain how this entire combination reaches the results.

Discussion phase (مرحلة المناقشة): هنا نتكلم إزاي أجزاء المشروع شغالة مع بعض في تناغم، وبتذكر دور كل جزء وتأثيره وببشغل إزاي؛ والهدف إنك تشرح ببساطة إزاي التركيبية دي كلها بتوصل للنتائج.

- The analytic phase. In here you go over the results and other key information like equations and parameter relations, explain what they mean as results and what specific deviations or results could mean or affect the performance of your project.

Analytic phase (مرحلة التحليل): هنا بتمر على النتائج وأي معلومات مهمة تانية زي ال equations والعلاقات بين ال parameters، وتشرح معناها كنتائج، وإيه معنى أي انحرافات أو نتائج معينة وإزاي ممكن تأثر على أداء المشروع.

- Ending/conclusion phase. In here you analyze what this project may mean for the future or the goals it will hopefully fulfill (completely optional).

Ending/conclusion phase (مرحلة الخاتمة): هنا بتحلل المشروع ده ممكن يعني إيه للمستقبل، أو الأهداف اللي بنتمنى يحققها (اختياري تماماً).

The introductory phase:

There's this tip which is "You start off your analysis by reconsidering the grand challenges"

فيه نصيحة منتشرة بتقول "You start off your analysis by reconsidering the grand challenges" (يعني ابدأ ال analysis بإنك ترجع لل grand challenges تاني).

We think this is really, really wrong considering that throughout your entire portfolio, you have an ENTIRE chapter dedicated to defining the grand challenges, connecting them and researching them. It is important to analyze them here once more so we don't argue that the grand challenges here can't be considered; however, that should be done so in a more natural fluid manner, and introductory sense to refrain from splitting them into two different parts which makes this a whole lot longer (introduction then grand challenges).

واحنا شايفين إن ده غلط جداً جداً، لأنك طول ال portfolio عندك chapter كامل مخصص لتعريف ال grand challenges وربطهم وال research عنهم. مهم إنك تحللهم هنا تاني، فاحنا مش بنقول إن ال grand challenges ماينفعش نتذكر هنا؛ لكن لازم ده يحصل بشكل طبيعي وسلس وبروح

المقدمة، من غير ما تقسمهم لجزئين منفصلين (مقدمة وبعدين) grand challenges، لأن ده بيطول الجزء جداً.

One of the best ways to hook a reader's attention (which is very important in this section to make sure a reader extracts the right amount of information well enough) is to start off with a side plot or statistic—a new insight is much advised. In the case of the analysis it is possible to start off with the problem to be solved or statement that we identified earlier, utilize an important **mind-blowing** statistic or piece of information. You connect it to the grand challenges in a backwards type of approach which helps inflate its importance so instead of

من أحسن الطرق إنك تشد انتباه القارئ (وده مهم جداً في الجزء ده عشان تضمن إنه ياخذ كمية المعلومات الصح بشكل كويس) إنك تبدأ بقصة جانبية أو إحصائية، ويُفضل جداً تكون insight جديدة. في الـ analysis ممكن تبدأ بالـ problem to be solved أو الـ statement اللي حددناه قبل كده، وتستخدم إحصائية أو معلومة مهمة **mind-blowing** (تخض). وتربطها بالـ grand challenges بطريقة عكسية، ودي بتكبر أهميتها. يعني بدل:

“problems A B and C are all connected by problem D because of X stats proving it is really bad and requires solving”

الأحسن تكتبها كده | you might find it more fluid or attention grabbing to go

“Whilst analyzing problem D we found that the statistic X was a clear product which also sprouted, realizing new branching effects on many challenges Egypt faces, some of which are problems A, B and C. It is believed that solving or putting efforts to suppress Problem D could have positive effects on many of the aforementioned challenges.”

An example for the mind-blowing statistic or insight is to analyze the problem's cause to something more scientific or quantifiable in a way whilst also connecting it to something people can understand and see for themselves—going “increased death rates due to CO₂ emissions” is more interesting than just “increased CO₂ emissions” because people understand how bad death is, but not necessarily CO₂ emissions (of course you can try and explain it further but it just spirals into more complexities). One time we did this by stating how heavy metals contaminate water and provided the Osmotic Pressure equation, explaining how it affects the local environment (people know how hard it is to find drinkable and clean water to an extent) and using that equation proving that statement. As you can see in the following example:

مثال على الإحصائية أو الـ insight الـ mind-blowing: إنك تحلل سبب المشكلة لحاجة علمية أو قابلة للقياس، وفي نفس الوقت تربطها بحاجة الناس تقدر تفهمها وتشوفها بنفسها. إنك تقول "increased death rates due to

"CO₂ emissions" أكثر إثارة للاهتمام من "increased CO₂ emissions" بس، لأن الناس فاهمة قد إيه الموت وحش، لكن مش بالضرورة فاهمة الـ CO₂ emissions (طبعاً ممكن تحاول تشرحها أكثر بس ده هيدخلك في تعقيدات أكثر). ومرة عملنا كده لما قلنا إن الـ heavy metals بتلوث المياه، وحطينا معادلة الـ Osmotic Pressure، وشرحنا إزاي ده بياثر على البيئة المحلية (الناس عارفة لحد ما قد إيه صعب تلاقي مياه نظيفة تتشرب)، واستخدمنا المعادلة دي عشان نثبت الكلام ده. زي ما هتشوف في المثال اللي جاي:

"Electronic waste, which typically releases heavy metals into the environment through **soil and water** was found to make up over 70% of water toxicity and pollution. This affects public health, especially in water since only 20% to 22.3% can be recycled effectively. Moreover, by increasing the amount of the leached electronic waste in the water, the **molarity (concentration)** of the heavy metals increases—making the water inedible and environmentally toxic—which increases the **osmotic pressure** because it is directly proportional to the molarity, where the formula of the osmotic pressure is $\Pi = iMRT$, where i is the *van't Hoff factor*, M is the molarity, R is the ideal gas constant, and T is the temperature in Kelvin. This makes the process of reverse osmosis to filter the water harder and consumes more energy in the filtration process, [according to **(CH.2.02)**]. This makes it much harder to improve the technological environment, reduce and adapt to climate change and pollution, and have recyclable waste as an option for material extraction. This is why E-waste is believed to be a major issue that must be attacked at the core of disposal by creating a project that prevents this line of events from taking place."

Here we were able to grab the attention using an important piece of statistical information to explain the scientific reasoning behind it as well as explaining what it means for the average human who doesn't know what heavy metals are or why they are bad and we finished off by connecting this statement to the grand challenges we believe are important for Egypt to confront.

هنا قدرنا نشد الانتباه بمعلومة إحصائية مهمة، وشرحنا الأساس العلمي وراها، وكمان شرحنا معناها للإنسان العادي اللي مايعرفش يعني إيه heavy metals أو ليه هي مضره، وختمنا بإننا ربطنا الكلام ده بالـ grand challenges اللي شايفين إنها مهمة إن مصر تواجهها.

This is a great opening since you quantify the problem's weight to the reader, they see that there's actually a need to stop this (if they want to keep drinking clean water).

دي بداية ممتازة لأنك بتبين للقارئ حجم المشكلة بالأرقام، فيشوف إن فيه احتياج حقيقي لوقفها (لو عايز يفضل يشرب مياه نظيفة).

You then immediately introduce your solution—the ground preparation phase—by stating how it tackles that specific problem. This phase is pretty straightforward and petite.

بعدها على طول بتقدّم الحل بتاعك، وده الـ ground preparation phase، بإنك توضح إزاي بيعالج المشكلة دي بالذات. والمرحلة دي بسيطة وقصيرة.

This is called the discussion phase, meaning that you do need to “Discuss” things, and here you’re going to want to discuss what actually made your project work and stand as it is while you’re writing this. This isn’t just throwing around equations and your “scientific base” to come to a conclusion that your projects works at the end (hooray I guess but no)

دي اسمها الـ discussion phase، يعني لازم فعلاً "تناقش" حاجات؛ وهنا هتناقش إيه اللي خلى مشروعك يشتغل ويبقى بالشكل اللي هو عليه وانت بتكتب. الموضوع مش إنك ترمي equations والـ "scientific base" بتاعك وخلاص عشان توصل في الآخر إن المشروع شغال (هيبه... بس لأ، مش كده).

You must discuss what each part is, its role, how it contributes and why it is the way it is. Also don’t frame this as “we did this and this happened so this is a success” this is basically how an uneducated person reaches a solution.

لازم تناقش كل جزء هو إيه، ودوره، وببساهم إزاي، وليه هو بالشكل ده. وكمان ماتقدّمش الكلام بشكل "we did this and this happened so this is a success" ده أسلوب واحد مش دارس بيحاول يبرر بيه الحل.

The EDP and scientific method are actually the exact opposite; “we found this phenomenon happens when in these conditions, since this was our goal we decided to replicate this by..... and at the end we reached the needed result” it is also beneficial to mention prior options you deduced to not be the most optimal, a good example goes as follows:

الـ EDP والـ scientific method عكس كده بالضبط: "we found this phenomenon happens when in these conditions, since this was our goal we decided to replicate this by..... and at the end we reached the needed result". ومفيد كمان تذكر الاختيارات اللي كانت قدامك قبل كده واستنتجت إنها مش الأمثل. ودي مثال كويس:

“With large computational data and quick changing parameters being in effect, it was deduced that it is mandatory to include a IC with a high enough frequency and computational power to satisfy the systems needs. While both Arduino and ESP32 are microchips that run calculations and automate responses effectively, Arduino would require an external internet or network based IC connection to transmit data to server. Not only is this less energy efficient, but also it demands and uses up some of the computational power and speed of the Arduino, deeming the ESP32 the optimal choice.”

This only needs the number specifics of their respective power and computation speeds as well as what the system you plan on building demands. Say you plan on building an adaptive system that stays in equilibrium even though changes occur every 3 seconds. The Arduino may issue orders every 4 seconds and by then the state of the system has already changed (you are in the present fixing the irrelevant past) whilst the ESP32 could issue the same commands with higher efficiency in just 2 seconds. This is the type of discussion you want, you want to explain and analyze your choices and what they mean in relation to the intended result.

ده محتاج بس الأرقام الخاصة بقدرة كل واحد وسرعة الحساب، وإيه اللي الـ system اللي ناوي تبنيه محتاجه. افترض إنك ناوي تبني adaptive system لازم يفضل متوازن رغم إن فيه تغييرات بتحصل كل 3 ثواني؛ الـ Arduino ممكن يدي أوامر كل 4 ثواني، ووقتها حالة الـ system تكون اتغيرت خلاص (يعني انت في الحاضر بتصلح ماضي مابقاش له لازمة)، بينما الـ ESP32 يقدر يدي نفس الأوامر بكفاءة أعلى في ثانيتين بس. ده نوع المناقشة اللي انت عايزه: تشرح وتحلل اختياراتك ومعناها بالنسبة للنتيجة المطلوبة.

A more concise example is as follows: | مثال أوجز

“In the circuit, the prototype’s microcontroller or ESP32 can provide 72Mbps of WiFi transmission speed, sufficient for local server communication at reliable speeds; however, rendering it ineffective in heavy-duty tasks such as AI-server and asynchronous communication. Therefore, it’d be too hard to manage an AI communication. It has an internal clock speed of 240MHz, far greater than its Arduino counterpart; allowing it to process much heavier tasks; however, none of these microcontrollers is suited for **heavy-duty computation per reading** (readings are at a frequency of 0.5Hz or 2 sec); hence, the best suited option is to upload the function data to the central server.”

This accurately explains why the ESP32 was chosen and why the implementation and usage of a central server was necessary.

ده بيشرح بدقة ليه اختاروا الـ ESP32، وليه كان ضروري نستخدم central server.

Another example of discussion is the prototype’s computation process, saying that it outputs certain variables or responses to a change in the environment. As seen in the following example

مثال ثاني على الـ discussion: عملية الحساب اللي بيعملها الـ prototype، يعني إنه بيطلع variables معينة أو بيستجيب لتغير في البيئة، زي ما في المثال اللي جاي:

(PH.2.14). Concerning the PID, the system uses the proportionality constant K_p to drive actuators to full power if needed according to the proportionality to the error signal $e(t) - K_p e(t)$. K_i is the factor of dependency on past errors, this eliminates and drives the system towards a safer state faster; however, more inefficiently. It does so by grouping up all of the previous taken up function variables; given as $K_i \int e(t)dt$ (MA.2.09). The D term of the PID signal is the derivative term which predicts the next reading providing damping and decreasing oscillation or inaccuracy. It's basically a learning tunable system driven by the overall behavior/response during runtime of the system. The derivative term is given as: $d(e(t))/dt$, providing an estimate to when $e(t)$ reaches its target. All of these are summed up and input into the system for logical deduction, as shown in **figure (5)**.

This discussion was able to explain what happens software-wise. Where using the inputs from sensors and running them through a PID system loop (a system that focuses on correcting deviations without a mathematical model predicting exact values) I don't want to bore you with the details of a PID's function but basically in this part it was explained how each variable helps the system know how much time is needed to keep the actuators on (another word for things you control like motors but with more functions like a humidifier or a Peltier that cools down the system). This is basically the logic of the system which you must discuss and explain. In here it was mentioned that this system basically learns and tunes its future responses referencing its past adaptations. What does this achieve you may ask? Not only are you obviously explaining how your system functions, this also helped show the fact that the system's efficiency tunes up and increases the more experienced it is (this explained the decrease in response time in our system because it kept getting better and faster which was showcased in the results)

المناقشة دي قدرت تشرح إيه اللي بيحصل من ناحية الـ software: إزاي بناخد الـ inputs من الـ sensors ونعديها على PID system loop (ده system بيركز على تصحيح الانحرافات من غير mathematical model بيتوقع القيم بالظبط). مش هزهقك بتفاصيل شغل الـ PID، بس باختصار الجزء ده شرح إزاي كل variable بيساعد الـ system يعرف محتاج يشغل الـ actuators قد إيه (الـ actuators دي الحاجات اللي بتتحكم فيها زي الـ motors، بس بوظايف أكثر، زي humidifier أو Peltier ببيرد الـ system). ده عملياً الـ logic بتاع الـ system، ولازم تتناقشه وتشرحه. واتذكر هنا كمان إن الـ system ده بيتعلم وبيظبط استجاباته الجاية بناءً على تكيفاته اللي فاتت. طب ده بيحقق إيه؟ غير إنك بتشرح الـ system شغال إزاي، ده كمان وضّح إن كفاءة الـ system بتتحسن وتزيد كل ما خبرته تزيد (وده فسّر قلة الـ response time عندنا، لأنه فضل يتحسن ويبقى أسرع، وده ظهر في الـ results).

By "Analysis phase", I mean that you need to analyze data you have, whether that'd be data you've acquired from your results or from mathematical models/AI models. You need to analyze what this data means and what it conveys or means for your prototype. After You reflected on how you actually got to this result or the feature that allowed you to easily achieve this result beforehand (discussion). You're also required to provide insight, meaning that you show what the results actually mean and what it could mean for people

trying to attempt this project. (For example, results may be varying depending on user, or for other people, results may vary for every trial, which you have to note down, stating whether it's a bad or a good thing and going the extra mile to talk about what this means if it was created on a large scale and stating that it may not be as accurate as your estimation deems it to be.)

بـ "Analysis phase" أقصد إنك محتاج تحليل الداتا اللي عندك، سواء كانت داتا من النتائج أو من mathematical models أو AI models. لازم تحليل الداتا دي معناها إيه وبتوصل إيه، ومعناها إيه بالنسبة للـ prototype. وده بعد ما تكون اتكلمت عن إزاي وصلت للنتيجة دي فعلاً، أو الـ feature اللي خلتك توصل لها بسهولة (وده الـ discussion). ومطلوب منك كمان تقدّم insight، يعني توضح النتائج معناها الحقيقي إيه، وممكن تعني إيه للناس اللي هتحاول تعمل المشروع ده. (مثلاً النتائج ممكن تختلف حسب المستخدم، أو ممكن تختلف من trial للثاني، ودي لازم تسجلها وتقول هي حاجة كويسة ولا وحشة، وتشغل زيادة وتتكلم ده معناه إيه لو المشروع اتعمل على نطاق كبير، وتقول إنه ممكن مايكونش بالدقة اللي تقديرك بيقولها).

NOW things get real sciency; you should start dissecting your entire project into different ideas with each idea consisting of a paragraph and optionally, a figure. If there is a relation between factors you have been studying in your project or something you calculate, it is mandatory to include a graph of that relation along with the that relation's equation. Every challenge or project will have at least one quantifiable quantity that has to have a point of comparison in relation to another (you will likely find this highlighted as a requirement in your challenge paper), this could be any of the following:

دلوقتي بقى الموضوع هيبقى علمي بجد: لازم تبدأ تفصّل المشروع كله لأفكار مختلفة، كل فكرة في فقرة ومعها figure (اختياري). ولو فيه علاقة بين عوامل انت بتدرسها في المشروع أو حاجة بتحسبها، يبقى إجباري تحط graph للعلاقة دي ومعها الـ equation بتاعتها. وكل challenge أو مشروع هيكون فيه على الأقل كمية واحدة بتتقاس ولازم يكون ليها نقطة مقارنة بكمية تانية (وغالباً هتلاقيها متحددة كـ requirement في الـ challenge paper)، وممكن تكون أي حاجة من دول:

- 1- Response time
- 2- Offset or deflection (bending in case of an architectural based project)
- 3- Energy production
- 4- Pollutant concentration (filtration based projects)

Each type of project has a way to determine its efficiency and this could come in various ways. Sometimes it is mandatory to include sometimes it isn't. To clear up any confusion, efficiency isn't just a "product per time", there are many types of efficiencies regarding any project ranging from cost efficiency [product vs cost], efficiency of usage [how easy it is to be used vs how well it performs], efficiency of maintenance [maintenance cost and time to complete vs how often it is needed]. These are strong scientific values because

they help you showcase how well your project performs while referencing real life industrial implementations and base efficiencies.

كل نوع مشروع له طريقة لتحديد كفاءته (efficiency)، ودي ممكن تيجي بأشكال مختلفة؛ ساعات بتكون إجبارية وساعات لأ. وعشان نشيل أي اختلاف: الـ efficiency مش بس "product per time"؛ فيه أنواع كتير من الكفاءة لأي مشروع، زي cost efficiency [المنتج مقابل التكلفة]، و efficiency of usage [سهولة الاستخدام مقابل جودة الأداء]، و efficiency of maintenance [تكلفة وقت الصيانة مقابل هي محتاجة قد إيه]. ودي قيم علمية قوية لأنها بتساعدك توضح مشروعك بيأدي قد إيه كويس، مع الرجوع لتطبيقات صناعية حقيقية وكفاءات مرجعية.

مثال لجزء مركّز على التحليل | An example of an *analysis focused part*:

"Further analysis showed that **there was a consistent error** as shown in **figure (4)**, this was due to the **limitations** presented by the *Nyquist frequency*, which states that the **maximum readable frequency is half of the sampling frequency (4000Hz)** after 2000Hz, **the accuracy decreases substantially**. This **sampling frequency** is appropriate because the **number of samples** is 128"

This part was able to analyze and give a well known scientific explanation for the decrease of accuracy above a certain threshold. What helps complete this paragraph is its analytical explanation of what this means for the project or the results "this sampling frequency is appropriate..." it basically deemed it as an issue that arose, but doesn't have any major drawbacks since the role of this system didn't need to exceed this threshold in any way or form. In short it fulfilled its part and succeeded.

الجزء ده قدر يحلل ويدي تفسير علمي معروف لنقص الدقة فوق حد معين. واللي كمّل الفقرة دي هو الشرح التحليلي لمعنى ده بالنسبة للمشروع أو النتائج "this sampling frequency is appropriate..."; يعني اعتبرها مشكلة ظهرت، بس مالهاش عيوب كبيرة لأن دور الـ system ماكانش محتاج يعدي الحد ده بأي شكل. باختصار: عمل دوره ونجح.

In another example: | مثال ثاني

it. For temperature, it relies on the incoming heat from the outside against the power generated by the peltier; given as: $\frac{dT}{dt} = \frac{Q_{peltier} - Q_{ingress} - Q_{internal}}{\rho C_p V}$ (MA.2.07). The **denominator** represents how hard the **prototype resists change**, given by ρ as the density of air, C_p as the coefficient of air transfer and V is the volume ($0.1375m^3$). The other two significant factors are $Q_{peltier}$ & $Q_{ingress}$ given as $Q_{peltier} = 0.0485 \times T_c \times I - \frac{1}{2} \times 2.07 \times I^2 - 0.484 \times \Delta T$ and $Q_{ingress} = 1.77 \cdot 0.5 \cdot \Delta T$. Calculated in Watts.

Graphing according to $T_h = 303.15K$ during the summer, where T_c is the temperature when cooled and substituting $I = 2A$ gives **figure (4)**. Analyzing the figure proves that so long as $f(x)$ or the **black line** overtakes the **blue line**, the **peltier can cool or heat**. Accordingly, $dT/dt = \sim \pm 0.1^\circ C/sec$, which is **in fact quite close to the 2nd trial** of the deviation test given that $C_p = 1005J/kg \cdot K$, $V = 0.13m^3$, and $\rho = 1.2kg/m^3$



Figure (4) representing $Q_{ingress}$ (blue) and $Q_{peltier}$ (black)

The equation for the change in temperature with respect to time was discussed. In this one particular example a graph of the relation between two opposing energy variables— $Q_{ingress}$ the blue line and $Q_{peltier}$ the black line—is shown. By priorly measuring the volume of the system and the internal energy (in this case only heat is predominant) and using norm values for the rest of equation's variables such as air density and air transfer ($Q_{peltier}$ is something you control through the ESP32 analog output {the stronger the signal the stronger it cools down the system}) $Q_{ingress}$ was the incoming heat from the electric components and the system passively heating up from its surrounding environment. This equation and graph helped determine when our system was efficient enough to overcome ingress and cool down the interior and also the minimum temperature we could reach (determined to be the intersection point between the two lines) However, this wasn't the most perfect analysis paragraph. See, the graph was a little miniscule making it hard to see and understand clearly, as well as the fact that this is an analysis section in the poster (where you are allowed to cut down on the definitions and explanations by including them in the presentation) which happened to be a little bit cramped. However, in the portfolio Analysis it was way clearer with the necessary distinctions and definitions.

هنا اتناقشت معادلة تغيّر درجة الحرارة مع الزمن. وفي المثال ده بالذات معروض graph للعلاقة بين اثنين energy variables عكس بعض: $Q_{ingress}$ (الخط الأزرق) و $Q_{peltier}$ (الخط الأسود). بقياس حجم الـ system والطاقة الداخلية قبلها (وفي الحالة دي الحرارة هي الغالبة)، واستخدام القيم المعيارية لباقي متغيرات المعادلة زي كثافة الهواء وانتقال الهواء (والـ $Q_{peltier}$ ده حاجة بتتحكم فيها عن طريق الـ analog output بتاع الـ ESP32؛ كل ما الإشارة تقوى كل ما يبرّد الـ system أكثر)، والـ $Q_{ingress}$ هو الحرارة الداخلة من المكونات الكهربائية ومن تسخين الـ system لنفسه بشكل سلبي من البيئة اللي حواليه. المعادلة والـ graph دول ساعدوا نحدد إمتى الـ system بقى كفاء كفاية إنه يتغلب على الـ ingress ويبرّد من جوه، وكمان أقل درجة حرارة نقدر نوصلها (اللي طلعت نقطة تقاطع الخطين). بس دي ماكانتش أكمل فقرة تحليل؛ الـ graph كان صغير شوية فصعب يتشاف ويتفهم

بوضوح، وكمان ده كان analysis section في الـ poster (اللي مسموح فيه تقلل التعريفات والشرح وتحطهم في الـ presentation) فكان مترحم شوية. لكن في الـ Analysis بتاع الـ portfolio كان أوضح بكثير ومعا الفروق والتعريفات اللازمة.

The general thought process behind actually doing all this requires you to be able to take your results, your prototype and your design requirements and combine all of these into one solid idea, mixing everything together, adding in a little bit of “Element X” (as in, references and citations that support your claims), and a bit of rhetorical thinking alongside new insights and advantages your project has provided, for example:

طريقة التفكير العامة ورا كل ده إنك تقدر تاخذ النتائج والـ prototype والـ design requirements وتجمعهم كلهم في فكرة واحدة قوية، تخلط كل حاجة مع بعض، وتضيف شوية “Element X” (يعني references و citations بتدعم كلامك)، وشوية تفكير إقناعي (rhetorical) مع insights جديدة ومميزات قَدِّمها مشروعك. مثلاً:

“This prototype model was particularly impressive at extracting heavy metals from water, giving the water a heavy metal **purity of >99.9%**.”

So long as the bolded words aren’t already in the results area and this is a conclusion from your results through an equation you used during your analysis, then this *is a new insight*. You concoct all of these to proceed into your *concluding phase*.

طالما الكلام اللي عليه bold مكانش مكتوب فال results و ده استنتاج من النتائج بتاعتك (يعني حاجة ممكن النتائج بتاعتك كانت بتلق عليها لكن مش هتتفهم على طول)، و انت شرحتها فال analysis باستخدام قوانين و هكذا، ف ده كده فعلاً منظور جديد للمشروع بتاعك او new insight! انت بتجمع كل الحجات ديه عشان توصل للمرحلة الخاتمة

That’s generally it regarding your analysis!

وده تقريباً كل حاجة عن الـ analysis!

Important notes!!!: | ملاحظات مهمة جداً

- You’re going to be putting little parentheses next to text that links to something in your curriculum like this:

هتخط أقواس صغيرة جنب الكلام اللي بيربط بحاجة في المنهج بتاعك، زي كده:

“This makes the process of reverse osmosis to filter the water harder and consumes more energy in the filtration process, according to **(CH.2.02)**”

You need to reference curricular learning outcomes at a minimum of 5 learning outcomes in your analysis.

لازم تعمل reference لـ 5 learning outcomes على الأقل من المنهج في الـ analysis بتاعك.

- Regarding the grand challenges themselves, you want to actually incorporate them into your analysis, talking about how your results solved that challenge, and if possible, if applied in real life, provide insight on how long it would take/how much it would cost and how effective it would be to apply your capstone. (conclusion or ending phase)

بالنسبة للـ grand challenges نفسها، لازم تدخلها فعلاً في الـ analysis، وتتكلم إزاي نتايجك حلت الـ challenge ده، ولو ينفع، لو اتطبق في الحقيقة، تدي insight عن هياخد وقت قد إيه، وهيتكلف قد إيه، وهيبقى فعال قد إيه تطبيق الـ capstone بتاعك (وده في الـ conclusion أو الـ ending phase).

- In-text citation is important and especially mention reference books or research papers of origin in regard to equations.

الـ In text citation مهم، وخصوصاً إنك تذكر الكتب المرجعية أو الـ research papers اللي جات منها الـ equations.

- Correctly and concisely label graphs and figures whilst sizing them up enough for someone to read at a distance.

اعمل label للـ graphs والـ figures بشكل صح ومختصر، وكبرها كفاية إن حد يقدر يقرأها من بعيد.

- Do not re-insert the results table here, discuss them instantly.

ماتحطش جدول النتايج تاني هنا؛ ناقش النتايج على طول.

- Do not leave a quantity or phenomena undiscussed or unanalyzed

ماتسيبش أي كمية أو ظاهرة من غير مناقشة أو تحليل.

There will be instances where some things are just measurable with no clear way to predict or control, simply stating this fact is sufficient in those cases.

هيبقى فيه حالات بعض الحاجات فيها بتتقاس وبس ومفيش طريقة واضحة تتوقعها أو تتحكم فيها؛ في الحالات دي كفاية إنك تقول الحقيقة دي.

- Do not make random graphs and relations between variables independent of each other. An energy to air humidity graph makes no sense and has no value to this section, please don't just inflate your writing for no reason.

ماتعملش graphs عشوائية وعلاقات بين variables مالهش علاقة ببعض. graph بين الطاقة ورطوبة الهواء مثلاً مالوش معنى ومالوش قيمة في الجزء ده؛ لو سمحت ماتتفخش الكتابة من غير سبب.

The following is an entire analysis & discussion: | Analysis مثال كامل لـ & Discussion

{

The test results demonstrate that the device was designed successfully to address the grand challenges and solve the core problem, which is **technological advancements and waste recycling**. The project mainly solves the problem of electronic waste, which typically releases heavy metals into the environment through **soil and water**. This affects public health, especially in water, because it is the main source of life. Moreover, by increasing the amount of the leached electronic waste in the water, the **molarity (concentration)** of the heavy metals increases, which increases the **osmotic pressure** because it is directly proportional to the molarity, where the formula of the osmotic pressure is $\Pi = iMRT$, where i is the *van't Hoff factor*, M is the molarity, R is the ideal gas constant, and T is the temperature in Kelvin. This makes the process of reverse osmosis to filter the water harder and consumes more energy in the filtration process, according to **(CH.2.02)**.

To address this problem, it was decided to make a scientific device, which is an oscilloscope, but all its electronic components must be recycled. The prototype handles the readings following four stages, which are the filtering stage, the amplifying stage, the DC bias stage, and the digital processing stage. The first three stages are **focused on hardware**, meanwhile, the **last stage is focused on computation and software**. This device **graphs** an input analog signal and using a certain mode, can **output certain variables** like the **frequency, amplitude, and the time of a period** (multiplicative inverse of **frequency**). The **results provided** are shown in **Table (3.02)**.

These results are a direct product of a complex mathematical computation (software) called a *Fast Fourier Transform (hereinafter referred to as FFT)*. This computation turns a complex wave into all its constituent waves, which is a law of summation of three main constituents, a DC bias (a DC component which is always the first sample and is never the peak frequency nor the peak amplitude), a sum of cosine waves, and sum of sine

waves. When an *FFT* process is called on a complex signal (same as a polynomial) (**MA.2.01**) incoming from the AUX input, it turns it into a cosine wave in one set of variables (called the **REAL SET OF DATA**), and a sine wave in the other set (called the **IMAGINARY SET OF DATA**). In both, a set of frequencies is plotted against an amplitude. The highest amplitude out of all is the frequency of the input wave. If the input signal were to be recalculated or reformed, it would be a summation of the DC and the two trigonometric functions. This reformation is given as: $\omega(t) = a_{offset} + \sum a_i \cdot \cos(2\pi f_i t + \phi_i) + \sum a_j \cdot \sin(2\pi f_j t + \phi_j)$, where a_{offset} is the **DC bias offset**, a_i is the i^{th} **amplitude** for the set of all amplitudes, f_i is the **frequency** at that **amplitude**, and ϕ_i is the **phase** of the **wave (horizontal transformation)**. Instead of summing up everything to achieve the complex wave, the *most important part* would be the wave with the **highest frequency**. Utilizing the **ArduinoFFT** library on the microcontroller, the complex wave was **dissolved** into a set of frequencies (TRANSFORMATION OF TIME DOMAIN TO FREQUENCY DOMAIN as shown in **figure (4.01)**) with their corresponding amplitudes. The frequency with the highest amplitude was chosen as this frequency was the result of the amplification and the hardware stage. This is shown in figure (4.02).

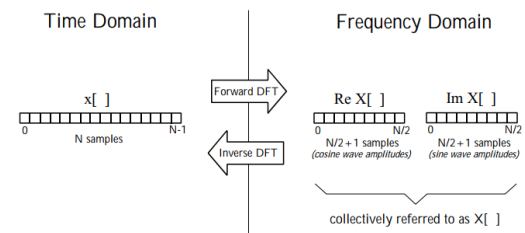


Figure (4.01), the forward and inverse transformation of a sample into its

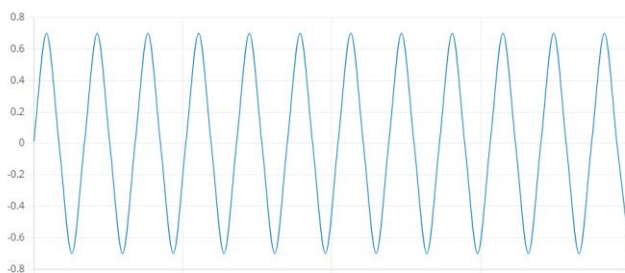


Figure (4.02), the simplified wave of the maximum frequency and amplitude of a complex wave of frequency 1000Hz on the serial plotter of the Arduino IDE.

For the

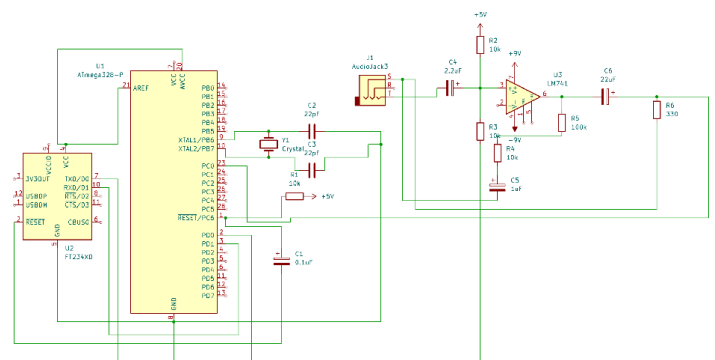


Figure (4.03), the schematic of the entire prototype.

hardware stage, as shown in the *methods* section, the prototype had two main stages of building, that's because Arduinos cannot be recycled: however, it's easy to find their microcontroller for reuse. Therefore, by following the

datasheet, a miniature Arduino development board was constructed. Capacitors **(PH.2.05)** were used as a way to provide an extremely stable **16MHz** speed or oscillation (using the crystal oscillator) to increase the processing speed of the microcontroller without damaging it. They were also used in the amplification stage for signal attenuation and filtering by making high-pass filters whose cutoff frequencies depended on the capacitors and resistors, where $f_{cutoff} = 1/2\pi RC$ **(MA.2.02)**. The resistors were wired in **parallel (PH.2.04)** to the **capacitor**. The chosen **frequency to be attenuated** was $\approx 16Hz$. This **had to be equal** across all **high-pass filters**. This related to the **accuracy design requirement** as this **boosted the accuracy** and **cancelled any low-frequency unwanted signal**. The **schematic for the entire prototype** is shown in **figure (4.03)**.

Further analysis showed that **there was a consistent error** as shown in **figure (4.04)**, this was due to the **limitations** presented by the *Nyquist frequency*, which states that the **maximum readable frequency** is **half of the sampling frequency (4000Hz)** after **2000Hz**, the **accuracy decreases substantially**.

This **sampling frequency** is appropriate because the **number of samples** is **128**.

Regarding the **entire**

prototype, its **power consumption** mostly relied on the **ATMega328P** because the **AUX** input had negligible **current and voltage output**. The **ATMega328P** pulled in a **consistent 5V** and a **consistent maximum current of 200mA (PH.2.03)**, according to the law of power: $P = IV$, Therefore, the power consumption of the ATMega328 is exactly **1 watt maximum**.

}

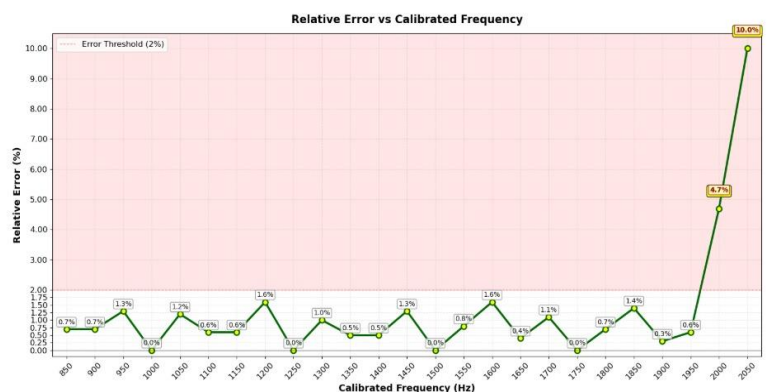


Figure (4.04), graph representing errors versus calibrated frequencies incremented at 50Hz per measurement.

Recommendations

The Recommendations section explains how the project could be improved in the future and how the selected solution could become more practical for real-life use. Recommendations should not simply repeat things the team should have done during the project; instead, they should focus on future improvements that were not realistically achievable because of limitations such as cost, available equipment, time, safety, scale, or technical complexity.

ال Recommendations بتشرح إزاي المشروع ممكن يتطور ويتحسن في المستقبل، وإزاي الحل اللي اخترتوه ممكن يبقى أكثر عملية وقابل للتطبيق علي أرض الواقع.

المهم هنا إن ال Recommendations مش مجرد ليست بالحاجات اللي كان المفروض تعملوها أثناء المشروع، يعني متجيش تقول “كان المفروض نعمل فولان أكثر” و يلا عك بقى و خلاص، ركز على تحسينات مستقبلية مأكانش واقعي إنكم تنفذوها بسبب limitations زي التكلفة، الأجهزة المتاحة، الوقت، الأمان، حجم ال Prototype، أو التعقيد التقني، كذلك.

Each recommendation should answer three questions:

1. What should be improved?

Clearly state the specific improvement being proposed.

2. Why would it improve the project?

Explain what problem, limitation, or weakness it would solve and how it would make the prototype or real-life application better.

3. Why wasn't it done in this project?

Give a realistic reason why the team could not implement it, such as:

- High cost
- Lack of specialized equipment
- Limited time
- Limited access to materials
- Safety concerns
- Prototype scale
- Technical complexity
- Lack of sufficient testing conditions

A strong recommendation therefore follows this general pattern:

Future improvement → Benefit → Reason it was not implemented

إليه اللي محتاج يتحسن؟
حدد بالظبط التحسين اللي بتقترحه.

ليه التحسين ده هيجلي المشروع أحسن؟
اشرح المشكلة أو الـ limitation أو الـ weakness اللي التحسين ده هيجلها، وإزاي هيجلي الـ Prototype أو استخدام الحل في تطبيق أرض الواقع أفضل.

ليه معملتوش التحسين ده بنفسكم في المشروع؟
أدي سبب منطقي يوضح ليه ماكانش ممكن تنفذوه وقتها، زي:
التكلفة العالية
مفیش أجهزة متخصصة متاحة
الوقت كان محدود
صعوبة الوصول للمواد المطلوبة في مصر
مشاكل متعلقة بأمان الطالب
حجم الـ Prototype كان صغير
التعقيد التقني

يعني من الآخر، الـ Recommendation القوية بتمشي كده:
تحسين مستقبلي → فایدته → ليه ما انتفذش في المشروع

As a tip, it is nice to start this section with a short introductory sentence explaining that the prototype demonstrated the feasibility of the selected solution but that further improvements could be implemented to either the prototype itself or its large-scale implementation, then, present 3–5 specific recommendations, preferably as bullet points.

Each recommendation should be concise but contain enough explanation to show why the improvement matters and why it was beyond the scope of the current project.

Tip صغير

حلو تبدأ ال recommendations بجملة قصيرة توضّح إن ال Prototype أثبت إن الحل قابل للتنفيذ من حيث المبدأ، لكن لسه ممكن يتعمله تحسينات، سواء في ال Prototype نفسه أو في تطبيقه على نطاق واسع علي أرض الواقع.

بعد كده، قدّم 3–5 Recommendations محددة، ويفضل تكون في شكل Bullet Points عشان تبقى سهلة في القراءة. كل Recommendation تكون مختصرة، بس فيها شرح كفاية يوضح ليه التحسين ده مهم وليه كان خارج نطاق المشروع الحالي.

Examples of types of recommendations to consider

Prototype

improvement:

Suggest a better component, stronger material, improved sensor, more accurate actuator, improved circuit, or more advanced control system.

Automation/control/viability:

Suggest improvements that would make the system more autonomous, responsive, or capable of adapting to different conditions.

Scaling:

Explain how the prototype could be adapted from a small demonstration into a larger mainstream application, and what infrastructure or technology would be needed, or a better location to implement it.

Economic/environmental

improvement:

Recommend ways to reduce operating costs, material consumption, water usage, waste, or environmental impact.

Here is an example of a full recommendations section:

Recommendations

The experience gained throughout the construction of the prototype has necessitated the inclusion of specific recommendations for future improvement and sustainability. There have been many pitfalls during the earliest stages during the prototype building, and the following recommendations illustrate the correct steps and protocols needed in avoiding them. The recommendations are:

- Oscilloscopes are expensive and hard to come by in Egypt, but they are needed to calculate the frequency and the power factor of the AC output, in order to determine the real power consumed from the current under the given load. This will help with correcting the power factor through choosing the correct capacitance of the capacitors after the full-bridge rectification using the diodes.
- Using microcontrollers and microchips such as Arduino-based chips, to take measurements and send real-time feedback of the water jet's flow rate and velocity, the turbine's RPM and the temperatures at the hot and cold junctions of the Peltier modules.
- The Toshka Lakes region presents an ideal environment for future deployment of a large-scale version of the prototype, as it offers both strong solar irradiance and a continuous freshwater source, making it perfect for activating both the hydroelectric and thermoelectric components of the system, additionally, choosing this location is strategic due to its remoteness and agricultural importance, making it a strong candidate for decentralized energy support in non-centralized areas of Egypt such as upper Egypt.
- For future large-scale applications, the system should be tested using more durable turbine materials and larger-scale water flow setups to reflect real environmental conditions. Since high efficiency thermoelectric modules and industrial-grade components were too costly for our prototype, they should be introduced gradually in the real-life application to boost performance. The design should also be adapted into a modular setup that allows for easier assembly and maintenance in rural

areas. This would make the system more practical for real deployment without needing massive infrastructure.

Learning Transfer

The following is a rule of thumb that seems to be a recurring question during evaluations:

دي قاعدة عامة لسؤال بيتكرر كثير في التقييمات:

- Learning Transfer is what you transfer over and use in your project

الـ Learning Transfer هو اللي بتنقله وتستخدمه في مشروعك.

- Learning Outcomes is the material you study and should learn by the end of this class.

الـ Learning Outcomes هي المادة اللي بتذاكرها والمفروض تكون اتعلمتها في آخر المادة.

This is going to be a short section since everything is almost all the same, so it's going to be like a template.

ده هيبقى جزء قصير، لأن كل حاجة فيه تقريباً شبه بعض، فهيبقى عامل زي template.

Do note: THIS IS NOT AN ACTUAL TEMPLATE THAT YOU *NEED* TO FOLLOW, DO YOUR OWN THING, BUT THIS IS AN EXAMPLE OF WHAT WE'VE COLLECTIVELY DONE AND TURNED OUT TO BE GOOD.

خد بالك: ده مش template لازم تمشي عليه، اعمل بطريقتك، بس ده مثال على اللي عملناه كلنا وطلع كويس.

Another note: this is NOT written in a table, the guide that says this meant it for the poster and the reference table at the end of the analysis is EXTREMELY space-eating; therefore, we discarded that ever since, now, it's way better to write in your own format.

ملحوظة ثانية: ده مش بيتكتب في table؛ الـ guide اللي بيقول كده كان يقصد الـ poster، والـ reference table اللي في آخر الـ analysis بياكل مساحة جداً، عشان كده بطلنا نعمله من ساعتها، ودلوقتي أحسن بكتير إنك تكتب بالشكل بتاعك.

You should order your learning transfers depending on subject, so:

لازم ترتب الـ learning transfers بتاعتك حسب المادة، يعني:

Math LOs used, Chemistry LOs used, etc., while grouping them up together.

Then you're going to write the name of the Learning Outcome with the code in between parentheses, like:

بعدين هتكتب اسم الـ Learning Outcome والـ code بناءه بين قوسين، زي:

Earth Science – Water Systems (ES.2.01)

You then list down the concepts you've used while transferring the learning outcome to reality and practicality. An extremely viable example of this would be:

بعدين تكتب الـ concepts اللي استخدمتها وانت بتنتقل الـ learning outcome للواقع والتطبيق. ومثال ممتاز على

ده:

Physics – Direct Current Circuits (PH.2.03)

Used concepts:

- Electric Current
- Potential Difference & Voltage
- Electrical Resistors
- Ohm's Law

Relation: Electric current is the **flow of charges** through your circuit. And the AUX input carries AC signals ranging from (-1V to 1V), so a DC offset of 2.5V to be in the safe range of the ADC (from 0V to 5V).

Voltage (potential difference) is the **driving force** that pushes current through your circuit. As current flows from high potential to low potential. The sound signals' voltage is the main variable measured, as the waveform's graph is between voltage and time. The microcontroller's ADC converts these voltages to digital data for frequency & amplitude calculation. The amplifier circuit lets more voltage flow to strengthen weak sound signals, so that the microcontroller can read them.

Resistors control current and set voltage levels. Electrical resistors were used in **voltage dividers** to scale the AUX input, so it doesn't exceed the microcontroller's ADC limits. And in filtration circuits (RC **High-Pass** filter) to remove noise in the sound signals.

Ohm's Law ($V = IR$) is the basis for constructing the entire circuit. Ohm's Law helped in determining resistor values for **input voltage protection**, so the AUX signal doesn't exceed ADC limits.

This is a good example because it takes the concept, explains it, rips directly from the project, links the concept to the project and how it was used or how it relates to what you're doing.

ده مثال كويس لأنه بياخد الـ concept، ويشرحه، وياخد من المشروع مباشرة، ويربط الـ concept بالمشروع وإزاي استخدم أو علاقته باللي بتعمله.

Pro tips while writing these: | نصائح احترافية وانت بتكتبها

- Use the skills and capstone connection sections of the curriculum file to know what to write about or what exactly needs to be linked.

استخدم جزئي الـ skills والـ capstone connection في الـ curriculum file عشان تعرف تكتب عن إيه أو إيه بالظبط اللي محتاج يترابط.

- You may add to the “Used Concepts” classification, “Learnt Skills” or “Skills Used”.

يمكن تضيف للتصنيف بتاع "Used Concepts" تصنيفات زي "Learnt Skills" أو "Skills Used".

More examples: | أمثلة تانية

Learning Outcomes

Math

MA.2.06

From understanding this learning outcome and how the limits and the continuity are defined to predict sudden changes in the prototype. Limits are defined as the value of a function that approaches as the input gets closer and closer to that point, and here is the form. $\lim_{x \rightarrow a} f(x) = L$. The limits are used to predict any unfamiliar disturbance that occurs in the prototype for illustration in the control system. If the parameter data increase suddenly, even if it does not exceed the limit, fluctuations occur. Limits are defined for every set point to make sure the prototype is working effectively. If the data passes the limit, then the actuators begin to work to make sure it returns to the set points defined. Continuity is used to determine if the prototype is working effectively through long periods of time because it needs to be working for at least 6 hours straight, and it is represented in graphs connected smoothly. Many types of discontinuities can happen during the operation.

- 1- Infinity discontinuity: Indicates an error in the connection, for example, jumper wires are not connected well, so the sensor produces large numbers that tend to infinity
- 2- Removable discontinuity: Indicates that there is a point at which the sensor did not produce data, so it leaves a hole in the graph
- 3- Step Discontinuity: Indicates that there is an error or disturbance that made the sensor data jump suddenly

List of Sources in APA Format

Throughout writing the portfolio you should Save all sites as you write because you will need to write them in this section in APA7 format. Send them in a group or save them in a word file as you want.

طول ما انت بتكتب الـ portfolio احفظ كل المواقع أول بأول، لأنك هتحتاج تكتبها في الجزء ده بصيغة APA7. ابعثها على جروب أو احفظها في word file، زي ما تحب.

How to cite in apa7 format: | citation بإزايا تعمل APA7

General format (Author, date, title, Source)

Author: List last name first, followed by initials (e.g., *Smith, J. A.*).

Author: اكتب اسم العيلة (last name) الأول وبعده الحروف الأولى من الاسم.

Date: Enclose the publication year in parentheses, (e.g., (2024)).

Date: حط سنة النشر بين قوسين.

Title: Use sentence case for book and article titles (capitalize only the first word and proper nouns). Italicize books and journal titles.

Title: استخدم الـ sentence case في عناوين الكتب والمقالات (يعني أول حرف في أول كلمة بس يبقى capital، والأسماء العلم). وخلي عناوين الكتب والمجلات العلمية italic.

Source: URL/DOI

Source: الـ URL أو الـ DOI.

General tips: | نصائح عامة

1) Avoid .com links and Wikipedia because their information is unauthorized

ابتعد عن لينكات الـ .com والـ Wikipedia لأن معلوماتهم مش موثقة.

2) For research papers and books you may find them in .com cites so don't put the .com URL. You will find in the research paper something called the DOI link use it.

(if you didn't find it you can ask AI to **JUST** the DOI link **NOT** to do the whole citation for you)

الـ research papers والكتب ممكن تلاقيها على مواقع .com، فماتحطش لينك الـ .com. هتلاقي في الـ research paper حاجة اسمها DOI link، استخدمه. (ولو مالتقيتهوش ممكن تطلب من الـ AI يجيبك الـ DOI link بس، مش إنه يعملك الـ citation كلها).

- 3) Don't make AI do the citation for you or use a citation generator. Because they do a lot of mistakes and often it doesn't complete the citation. And also they are recognizable by evaluators and you will lose marks.

ماتخليش الـ AI يعملك الـ citation، وماتستخدمش citation generator، لأنهم بيغلطوا كتير وغالباً مايبكملوش الـ citation، وكمان المقيمين بيعرفوهم وهتخسر درجات.

- 4) Sometimes in research papers and books it is better to add the volume number and the page range where the information you got exists.

ساعات في الـ research papers والكتب الأحسن تضيف رقم الـ volume ونطاق الصفحات اللي فيها المعلومة اللي أخذتها.

أمثلة | Examples:

D. N. Rockmore, "The FFT: An Algorithm the Whole Family Can Use" in Computing in Science & Engineering, vol. 2, no. 01, pp. 60-64, January/February 2000, <https://doi.org/10.1109/5992.814659>

Kamisuna, T. (2025, August 7). Japan's "urban mining" and economic security. <https://www.iiss.org/online-analysis/online-analysis/2025/08/japans-urban-mining-and-economic-security/>