Engineering: You're Hired – Project Submission Form

Please use this template for your submission, outlining your design and your plan for a project to take it to proof of concept stage. You should submit the entire document including the Team Leader names and Daily Team Reviews.

Hub: 19

Team: A

Project Title: Making Homes Smarter

- ❑ **Confirm participation in Engineers In Business competition** (right click checkbox and change to check mark)

Technical Design

1) Aim, impact & commercial implications

This section should state what your proposal aims to develop, the impact this will have on key stakeholders (e.g. the company, customers and society at large), what the route for commercialisation of your proposal is and what the competing technologies are.

a) Define/Understand the problem

Identify the problems that are involved in your projects and consider:

- *What components can your solutions address with regards to the problem? (energy, logistics, software, materials)*
- *How should your solution improve the problem? (higher yield, higher efficiency, simpler-to-use)*

Smart homes

Smart homes should aim to make life easier and more efficient for the residents, either through the introduction of new technologies, or making current devices more 'streamlined' (e.g. controlling heating remotely). For example, to combat energy overuse a number of smart home technologies can be employed e.g. using a smart thermostat. An effective smart home technology should be relatively inexpensive to purchase, secure for the user and overall, should make living easier for individuals.

One problem within the home at the moment is food waste - food waste costs the average UK family £800 per year[3] and also generates approximately 19 million tonnes of CO_2 emissions each year[2]. Our aim throughout this project is to reduce food waste in the typical working family home by keeping families aware of what food they have at the moment and when they should use it by. We shall do this through the introduction of a smart food hub.

b) Understand the context of the problem

Identify the key stakeholders in which your problem involves. Perform a STEEPLE analysis by considering:

- *The key funders to your problem (by addressing the problem, who will the problem involve?)*
- *The users (who will use the solution)*
- *The buyers (who pays for the solution, note: the user is not necessarily the buyer)*

Stakeholders:

- Manufacturer
- End User
- Government
- Health Organisations
- Customer / Landlord
- Rival companies

The STEEPLE Analysis:

- **Social**
  - Manufacturer - ensure it is *needed* by consumers
  - End User - making day to day life more convenient/ automated
  - Rival companies - advertisements on social media
- **Technological**
  - End User - easy to use and implement into home
  - Manufacturer - ensure it is able to learn and adapt in the home
- **Environmental**
  - End User - how much power is used
  - Manufacturer - environmentally friendly and sustainable
  - Government - responsible to supervise pollution emission
- **Economic**
  - Rival companies - take into account price of rival product
  - End User - how much money is saved when taking into account the price of the product/service
  - Government - is it possible to affordable and widely-spread by as many as customers
  - Manufacturer- low cost of production and integration
- **Political**
  - Health Organisations - Political policies describe all sorts of policies regarding healthcare and when the government changes these policies also change.
- **Legal**
  - Rival companies - copyright/patented material
  - Manufacturers - does it meet regulations for production
- **Ethical**
  - Health Organisations - safe and accessible for all users
  - End User - safe and secure from attacks (unauthorised access)

c) Quantify the problem and define the design question

Consider the key numbers to the problems that have been identified and begin developing a SMART design question. Consider:

- *The value of the problem (how much energy is being lost and roughly how much money is that worth?)*
- *The value to the consumer/stakeholders?*
- *S.M.A.R.T analysis - check whether your question fits the SMART criteria*

The New Design Question: We want to design a system to aid working families in reducing food waste, saving money and improving diet, with an aim to reduce food waste by 30% and food bills by £200 per person, per year in 6 months.

S - Design a 'smart' addition to a busy, working family home that will assist in reducing food waste and the costs associated with food waste.

M - Reduce food waste in a typical 4-person family home by 30% and save £200 per person per year on food shopping bills.

A - House needs to be able to monitor food content and expiration dates without too much user input (e.g. image recognition software), costs should be lower than the amount of money spent on wasted food in order to be a viable solution, financial return within 2 years.

R - There is a big food waste issue within the UK (7.3m tonnes wasted in UK households in 2015[1]), which costs the average person in the UK £200 per year - relevant for reducing household costs.

T - Aim to develop the physical system within six months to a year.

2) Design Specification

This section should provide the engineering approach to setting the design specifications and criteria of the solution. Emphasis should be made to design your specifications and criteria to ensure the solution will be useful to the key stakeholders. Consider:

- *Based on the SMART analysis, is it possible to propose a set of specifications?*
- *What design specification(s) are musts (redline)? (The criteria in which must be met to ensure the solutions are practicable, e.g. cost must be kept low per unit)*
- *What are the desirable specifications? (achieving maximum yield/efficiency, the previous infrastructure shouldn't be inhibited)*
- *Are the specifications comparable? (can each specification be compared to one another in terms of importance to the stakeholders?)*

Specifications

(Red indicates must whilst black indicates desirable)

- Able to track food usage
- Size and portability
- Fast-freeze
- Should be able to track all kinds of produce (even without labels)
- Have a database of recipes
- Track dietary requirements/preferences
- Links with user's shopping account
- Rechargeable battery
- Voice recognition
- Manually able to input/remove food
- Childproof
- Easy to maintain / update
- Ease of use
- Cost
- Reduces food waste

3) Brainstorming and Conceptual Design

This section should display the <u>multiple</u> possibilities and considerations for the solution to the problem. Consider including:

- *A brief description of the brainstorming process and methodology*
- *A mind-map which includes the final set of concepts. These concepts are annotated with rough notes; this may include key functionalities, performance characteristics, novelty.*

The various options that we had considered while brainstorming are as follows:

Option-1 (Tablet):

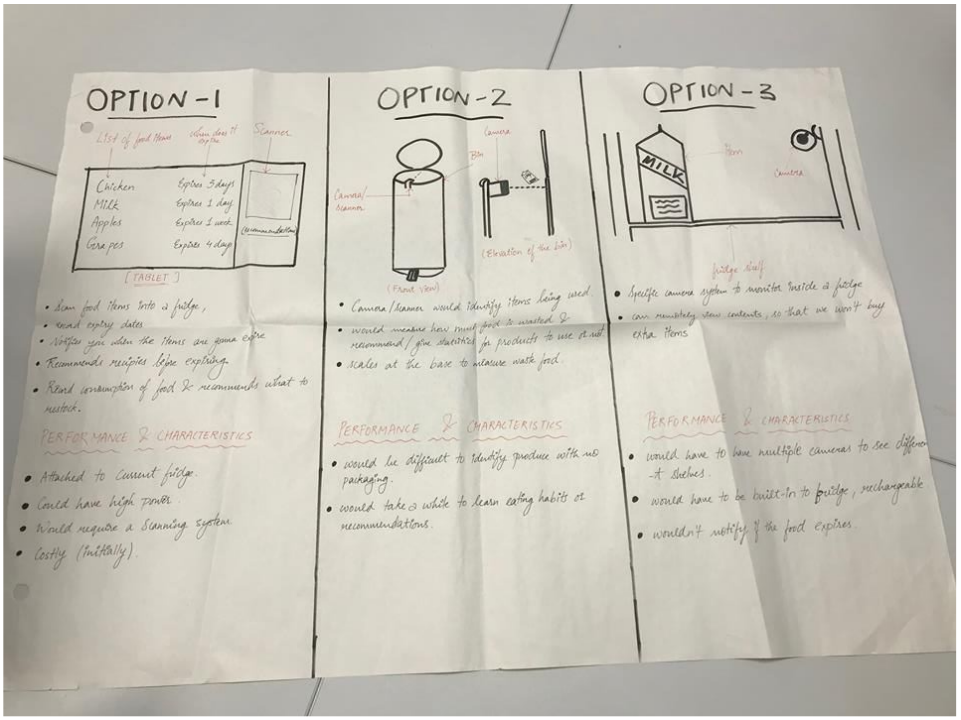
- Scan the food items into a fridge.
- Record expiry dates.
- Notifies when the items are going to expire.
- Record consumption of food & recommends what to restock.

Option-2 (Bin):

- Scan empty packaging to record what food has been consumed/wasted.
- Recommends ways to reduce food waste based on consumption habits.

Option-3 (Camera):

- Specific camera system to monitor inside the fridge
- Since we would know what items are already in the fridge, it would prevent us from buying extra items.



4) Conceptual Design Selection

This section should provide a rigorous approach to <u>selecting</u> your final design using an appropriate method of choice with justification. Consider including:

- *A brief description of why the final concept is chosen (methodology included).*
- *Explanation of criteria ranking*

We chose this concept by integrating the ideas of Option-1 and 2. Our main aim as stated was to target a working family and reduce their food wastage without costing them too much. So, our design just includes a tablet with a scanning system. The general overview of our design is as follows:

- The tablet unit is with a barcode scanner.
- Scan the barcode of the food item that we are going to store in the fridge. This will record the expiry date of the item.
- For food items without a barcode scanner we also have an option to manually input about the product.
- The tablet would display a list of items in the fridge and highlight the ones which would expire soon.
- The tablet is also connected to the internet to find a variety of recipes for the products that expire soon.
- The tablet also has 2 options as in **Scan In** and **Scan Out**. The significance of both these options are we use **Scan In** to place an item in the fridge whereas **Scan Out** to remove an item and then scan it so that it records when an item is used.
- An additional feature we also have is **Voice Recognition** which is basically used for checking out.
- When the tablet learns that some products have been used it would also give recommendations for example: (Buy eggs every two weeks instead of one) to avoid food wastage.
- The tablet is powered up using a normal plug socket.

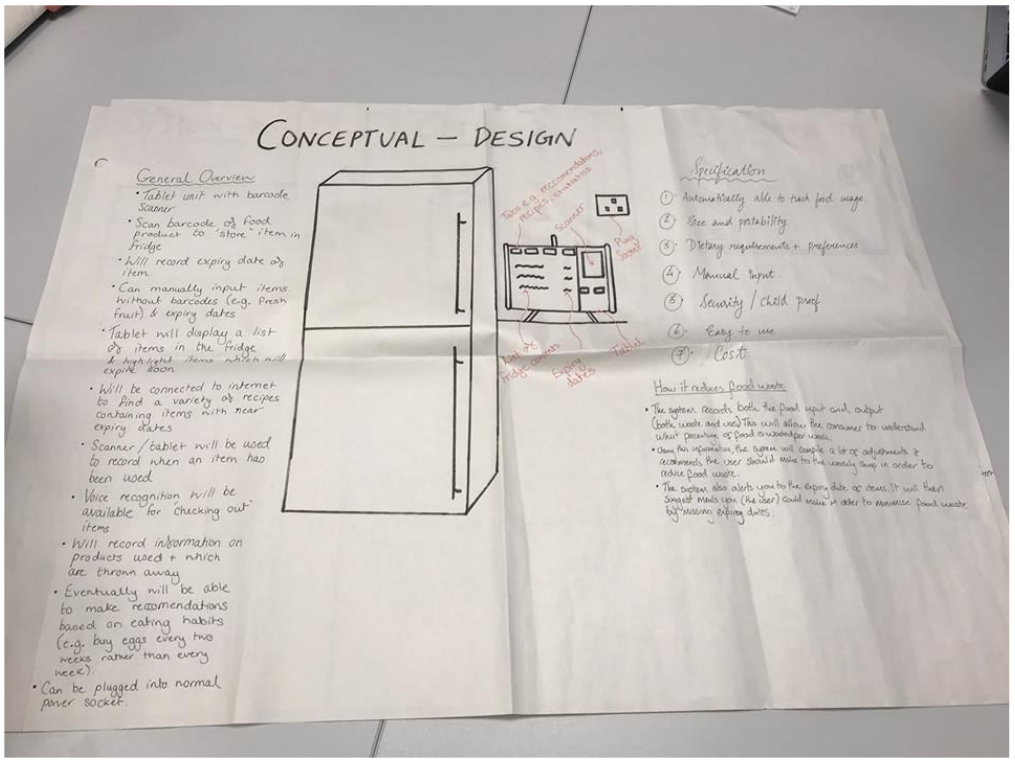
<u>Decision Matrix and Criteria Matrix</u>:

	Automatically able to track food usage	Size and Portability	Dietary requirements + preference	Connect to shopping account	Manual input	Security/Childproof	Ease to use	Cost	Reduces food waste	**Total**	Weighting
Automatically Able to track food usage		1	1	1	0	1	1	0	0	**5**	7
Size and Portability	0		1	0	0	0	0	0	0	**1**	3
Dietary requirements + preferences	0	0		0	0	0	0	0	0	**0**	3
Connect to shopping account	0	1	1		0	1	0	0	0	**3**	6
Manual input	1	1	1	1		1	1	0	0	**6**	8
Security/Childproof	0	1	1	0	0		0	0	0	**2**	4
Easy to use	0	1	1	1	0	1		0	0	**4**	6

Cost	1	1	1	1	1	1	1		0.5	**8.5**	10
Reduces food waste	1	1	1	1	1	1	1	0.5		**8.5**	10

After evaluating the criteria matrix, we came up with the decision matrix. As shown, the highest score that we obtained is for the Tablet (Option-1) and then the Bin (Option-2). Tablet scores 351 whereas the Bin scores 268 because of which we collaborated and came up with our final design. Note that we decided to ignore some criteria, as we felt like they were 'future features' which could be implemented down the line, but not essential.

		Tablet	**Tablet**	**Bin**	**Bin**	**Camera**	**Camera**
	Ranking	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
Reduces Food Waste	10	8	80	2	20	1	10
Low Cost	10	5	50	8	80	3	30
Manual Input	8	10	80	1	8	1	8
Automatically Tracks Food Usage	7	9	63	8	56	1	7
Ease of Use	6	7	42	8	48	6	36
Connect to Shopping Account	6						
Security/Childproof	4	3	12	8	32	9	36
Size + Portability	3	8	24	8	24	1	3
Dietary Requirements + Preferences	3						
Total			351		268		130



The above photo is a small representation of how our design would look, and gives a general overview of how it would work to reduce food waste.

5) The feasibility of your conceptual design

Including:

a) *Present your design showing how different disciplines have contributed to key features of the design. This might include human factors design, materials selection, control systems, energy/power requirements, computational requirements, limitations of the design, health and safety issues.*

b) *Show the feasibility calculations that demonstrate your design works.*

In computer science, we solve real-world problems by working in teams, dealing with clients and employing programming and coding to design and build complex software creations. We have extensive knowledge with regards to networks and wifi connectivity, which would prove extremely useful when designing a 'smart home' project as the majority of this kind of technology is interconnected wirelessly. We also thoroughly understand the mathematics and theory behind encryption algorithms such as RSA, and understand the importance of 'hashing' and 'salting' to achieve maximum security. Furthermore, we know from experience how to calculate professional estimates for timescales and levels of difficulty in creating software products. We need to be able to know how secure software is, how long it will take to design and develop, how much it will cost (with regards to both software and hardware), how we will connect the device(s) and finally the speed and efficiency of the system.

In Automatic Controls and Systems Engineering we are used to working with mechatronic systems, therefore combining different aspects of Mechanical and Electrical engineering with Computer Science. The hardware designing and implementing experience we have, combined with the software experience of the Computer Science students and the digital analysis of the Electrical Engineering students can help this project develop successfully. Furthermore, control engineering applies automatic control theory to design

systems with desired behaviors in control environments.For instance, a heater with a reference value set and a temperature sensor, that would turn on until the reference value set by the user is reached, and then turns off.

In electrical engineering, we are devoted to studying the communications system and electrical energy conversion. We usually pay more attention on the analogue and digital analysis to give assistance to take better advantage of energy. We are able to create and identify the signals from a device and raise the efficiency of energy usage from what we learn. It is quite useful for this project 'make your home smarter', including make the design as affordable as it can.

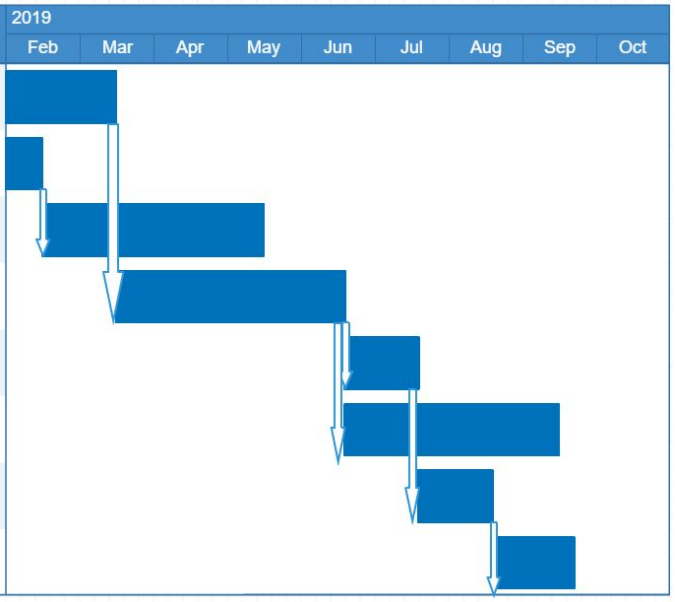
In civil and structural engineering we look at how infrastructure and buildings can be made to be sustainable and improve society and the quality of life by ensuring it meets the needs of the future and the present. In order to truly create smart homes the technologies created would need to be implemented into the very structure of the building to create maximum efficiency within. For example, things can be integrated into the walls in order to maximise space and ensure more comfort.

Project Management

1) Project planning & Time Mapping

- *Indicate the planned duration of your project, the principal activities and resources (people, equipment and materials) required for the design and development of your proposal up to the prototype. Include a Gantt chart showing the principal activities.*

Process	Tasks	Duration (months)
1.0	Contract software consultancy	1.5
1.1	Source hardware	0.5
2.0	Manufacture hardware	3
3.0	Software development	3
4.0	Software testing	1
4.1	Marketing	3
5.0	Integration of software and hardware	1
6.0	Final testing	1



The Gantt chart above shows the expected duration of each of the principal activities within our project. The total expected duration of the project is 7.5 months, however this value depends on the process running with no delays. Overall, we would suggest that the project would be completed within 9 months in order to give a unexpected delay contingency of 1.5 months (20%).

2) Project Risk Management

- *Identify what could go wrong with the PLAN of your project (commercially, technically, timescale etc.) and how you will mitigate these risks. Include*

Sourcing of Hardware:

Risk: Missing pieces of hardware or failure in sourcing the hardware, Low Probability but High Impact.

Mitigation: Keep a strong check like the number of tablets ordered and that we have received is equal and that they are up to standard and meet the specification.

Database Management System:

Risk: Database breach and security risk, Medium Probability but High impact

Mitigation: Apply RSA algorithm and use Hash which are the most preferred security measures to make the database more secure and not give access to attackers.

Developing Software:

Risk: Proper procedure while Development, Deploying and resolving Bugs, Medium Probability but High Impact

Mitigation: Use AGILE methodology which uses incremental, iterative work sequences that are commonly known as sprints. Furthermore, schedule more developers and testers due to unexpected circumstances.

3) Project Costing

- *Identify the different types of project development and production costs. Provide a detailed breakdown of personnel costs (based on the information given to you on Thursday). If possible, provide an estimate of the project development (capital) and production (operating) costs - with justifications.*
- *How much money are you pitching for?*

We have decided that a team of 6 people will be needed for the successful completion of the project and in order to cover every aspect of the development process.The team we would look to hire would consist of a senior software developer, two software developers, a graduate software developer, a hardware engineer and a PR manager. We would hire them all for 6 months, apart from the PR manager which we would instead hire for only the final 3 months of the project. The employer would have to pay each team member's base salary, combined with taxes (income tax, national insurance, etc.) and also any additional costs.

1 x senior software developer £50k -> £59k -> £118k (only need 6 months) => £59k [4] [5]

2 x software developer £35k -> £38k -> £76k (£152k for 2) (only need 6 months) => £38k (x2) [4] [5]

1 x graduate software developer £25k -> £27k -> £54k (only need 6 months) => £27k [4][5]

1 x hardware engineer £33k -> £36.5k -> £73k (6 months) => £36.5k [4][5]

1 x PR manager £33k -> £36.5k -> £73k (3 months) => £18.25k [4][5]

Total for employees: £216,750 (for 8 month project)

We would import the 'hub' units in bulk costing us only £60 per unit and would then market the units at £134.99. We would aim to sell 2500 units in the first year and 3500 in the second. This would result in an overall loss of £29,275 in the first year, but a profit of £262,465 in the second. This would mean overall, over the two years the company would make a profit of £233,490. Assuming the sales over the course of a year are distributed linearly, we estimate the break-even point to be around March time in the second year.

4) Patent implications

- *Identify any areas of your proposal that you feel may be commercially sensitive or may require protection, and any areas where you reply on already protected technology.*

One part of our food management hub which may be commercially sensitive and require secrecy/protection would be the software we would develop in order to scan barcodes and store information about expiration dates. The rest of our hub would use already protected technology e.g. barcode scanners, touchscreen software and so wouldn't need to be patented etc

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References

References

[1]"Household food waste level 'unacceptable'", *BBC News*, 2017. [Online]. Available: https://www.bbc.co.uk/news/science-environment-39747327. [Accessed: 31- Jan- 2019].

[2]"London's food waste facts", *Recycle for London*, 2019. [Online]. Available: https://www.recycleforlondon.com/london-food-waste-facts. [Accessed: 31- Jan- 2019].

[3]"Food Surplus & Waste in the UK", *Wrap.org.uk*, 2018. [Online]. Available: http://www.wrap.org.uk/sites/files/wrap/Food-Surplus-and-Waste-UK-Key-Facts-23-11-18.pdf. [Accessed: 31- Jan- 2019].

[4]"PayScale - Salary Comparison, Salary Survey, Search Wages", *PayScale*, 2019. [Online]. Available: https://www.payscale.com/. [Accessed: 31- Jan- 2019].

[5]"Gross Salary to Total Cost Calculator", *Stafftax.co.uk*, 2019. [Online]. Available: https://www.stafftax.co.uk/employers/salary-calculators/gross-salary-to-total-cost-calculator?fbclid=IwAR1AFfpvET1dimUndXbfQ3yIxCq8qin-wGM_E6k75Wc9kLEkFGRF2ti-7cA.

Daily Team Review

Day	Engineering Theme	Important skill on this day	Team leader(s)
Monday	Define	Communication	Vlad
Tuesday	Decide	Problem solving and decision making	Sree
Wednesday	Data	Working under pressure and networking	Samuel
Thursday	Develop	Delegation and report writing	Luke
Friday	Defend	Time management and presentation preparation	Chao, Lydia

Team Review (remember to use professional language and approach in your review). Consider the following and provide evidence where appropriate: ● Implementation of any changes recommended from the previous day(s)? ● What your day's objectives were, how well you achieved them and reasons why you may not have achieved them in full? ● How effective the team leader was and any difficulties? ● How well the team worked as team? ● The teams behaviours (e.g. bringing in, shutting out, proposing, building).	
Monday:	
What went well?	We communicated well to brainstorm ideas regarding the brief, Each member got a chance to communicate their ideas, and everybody offered constructive criticism. The team discussion was very effective, as we had listed out all the stakeholders and followed the STEEPLE analysis successfully. The changes from previous days are not applicable.
Any difficulties?	We had the pressure of time and should've thought to organise the plan in a much better way. We struggled to understand the format of the presentation, but after the feedback realised our errors.
Anything different that you want to do tomorrow?	Be more prepared for presentations and manage our time more effectively as a team.
Tuesday:	
What went well?	Better prepared for boardroom presentation, brainstormed ideas well and

	combined them, focused design question to be more specific, split up pieces of work to improve efficiency, we collaborated and built on each others ideas.
Any difficulties?	Had to adapt some ideas based on recommendations from advisor.
Anything different that you want to do tomorrow?	Be more enthusiastic in presentations.
Wednesday:	
What went well?	Got good feedback from the presentation Team works very well together.
Any difficulties?	Need to finalise numbers better.
Anything different that you want to do tomorrow?	Prepare even more for presentations, making sure all cost is factored in.
Thursday:	
What went well?	We had split the tasks between us for the day to fill out sections of Project Management which turned out to be very efficient and also finished our tasks before the deadline. Team worked very well together.
Any difficulties?	Had to finalise the costs better.
Anything different that you want to do tomorrow?	Prepare and give our best output for the final presentation tomorrow.