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TIM 105
11/11/17

HW6

1. Functional Decomposition of a Personal Computer:

Perform a functional decomposition of a personal computer. First do a simple dissection of the product using the FAST technique; restrict this dissection to the major subsystems of the product. Then create a function structure (FS) for the product as follows. Start with a single block showing the overall function, inputs and outputs of the product. Then decompose this product into sub-functions, and draw the function structure (at least 3 levels deep) for the products. Clearly identify the material, energy, and information flows into and out of each subsystem or component. Describe the differences between the FAST diagram and Function Structure.

Step 1: Define the real problem.

SP1: Dissect the Personal Computer using the FAST technique.

SP2: Create a Function Structure (FS) for the diagram.

SP3: Describe the differences between the FAST diagram and the Function Structure.

Step 2: Plan how to solve the problem.

What assumptions do I need to make: I am an engineer decomposing a personal computer to understand the differences between a FAST diagram and a Function Structure.

What information is available: Lecture notes on the FAST technique to product decomposition, the PD&D book, and internet research on how personal computers work.

SP1: Dissect the Personal Computer using the FAST technique.

Step 1: Understand how personal computers work.

Step 2: Make a list of the important subsystems and components that are relevant to my FAST diagram.

Step 3: Make a list of the key functions and subfunctions of the product.

Step 4: Write down the main function of the product.

Step 5: Organize the “bones” of the FAST diagram by working from the outsides in.

Step 6: Create a FAST diagram for our product.

SP2: Create a Function Structure (FS) for the diagram.

Step 1: Identify the main function of the product, and the inputs and outputs of the product.

Step 2: Identify the sub-functions of the product and create a transparent box model.

Step 3: Draw the system boundary.

Step 4: Identify the subsystems and components needed to perform the sub-functions

Step 5: Identify the material, energy, and information flows that go into creating the components in the product.

Step 6: Draw the final FS diagram.

SP3: Describe the differences between the FAST diagram and the Function Structure.

Step 1: Describe the differences.

Step 3: Execute the plan.

SP1: Dissect the Personal Computer using the FAST technique.

Step 1: Understand how personal computers work.

Step 2: Make a list of the key functions and subfunctions of the product.

Functions	Sub-functions
- Runs an operating system to interface between the user and the microprocessor	- Processor management - Device Management - Receive inputs from user - Data processing - Display output
- Runs software applications designed for specific work or play activities	- Maintain an Application Interface - Display processed data - API to allow applications to use OS functions
- Data Management	- Memory management - Storage Management - Can store data and retrieve stored data

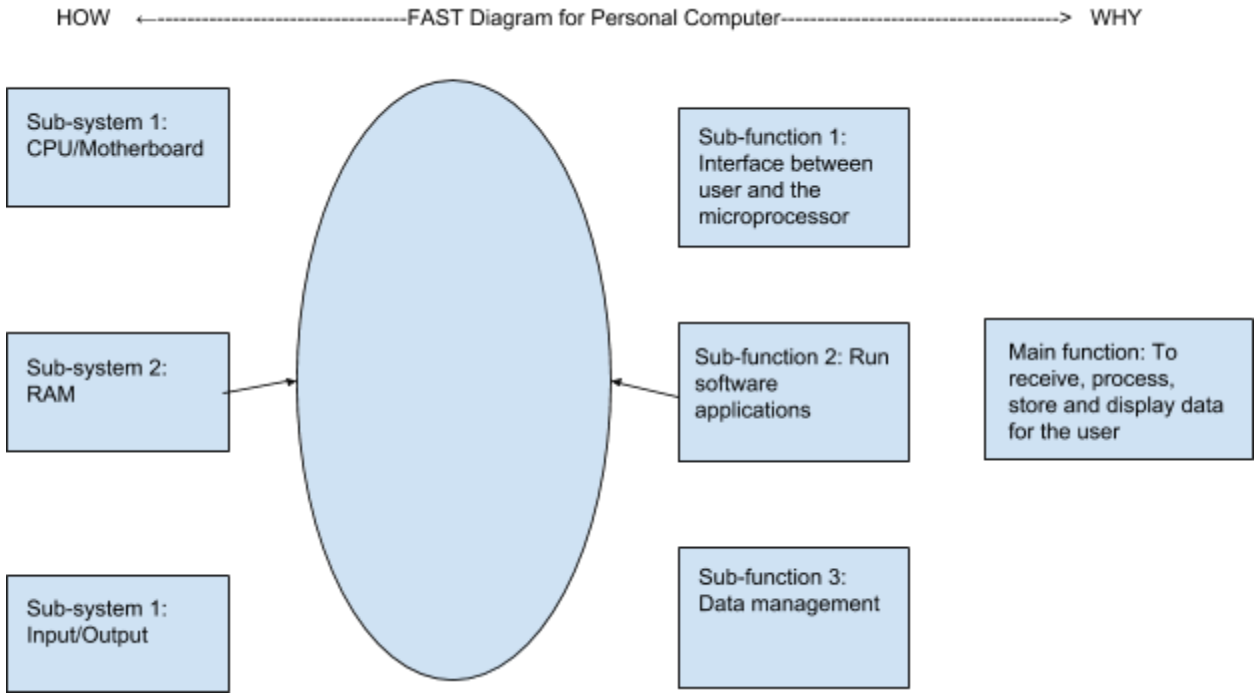
Step 3: Make a list of the important subsystems and components that are relevant to my FAST diagram.

System	Subsystems	Components
Personal Computer	CPU/Motherboard	- ALU - Control Unit - Registers
	RAM	- Circuit Board - Clock - Memory Banks - SPD chip - Burst Counter
	Input/Output	- Keyboard - Mouse - GUI/Display Screen - Speakers - Headphone jack

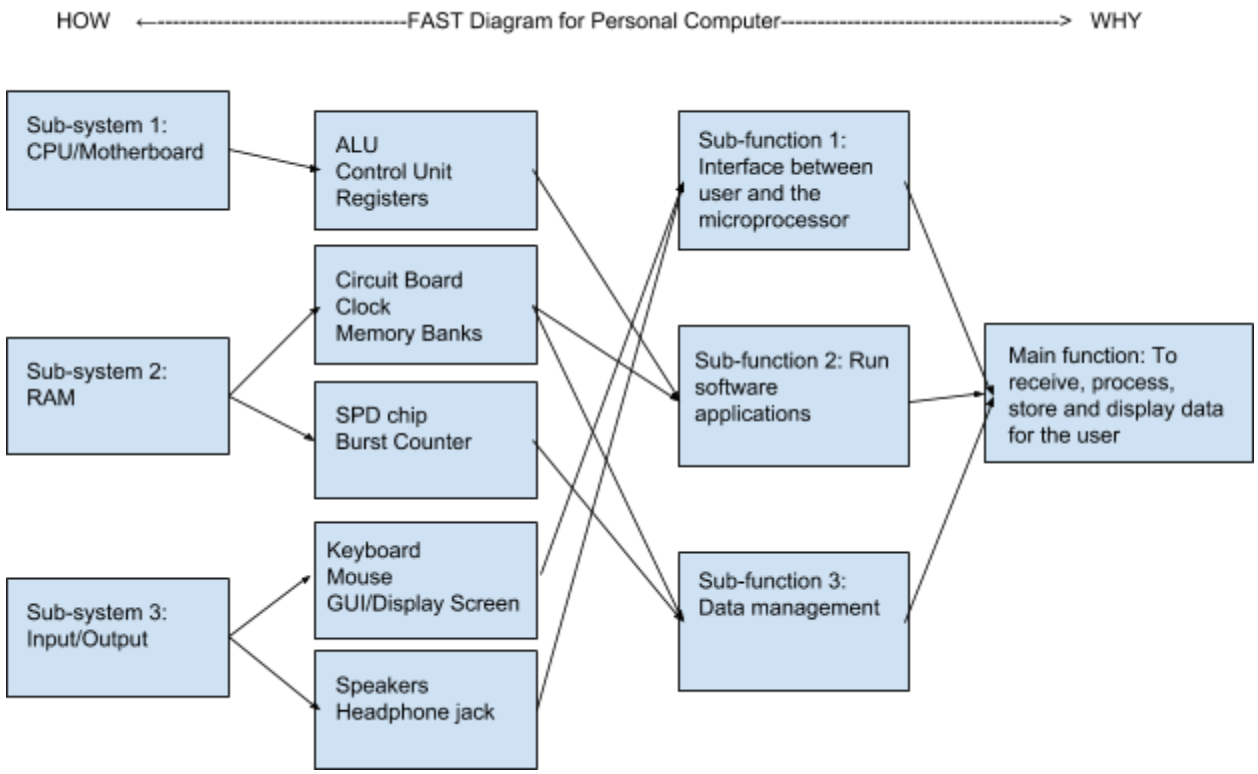
Step 4: Write down the main function of the product.

The main function of a personal computer is to receive, process, store and display data.

Step 5: Organize the “bones” of the FAST diagram by working from the outsides in.



Step 6: Create a FAST diagram for the personal computer.



SP2: Create a Function Structure (FS) for the personal computer.

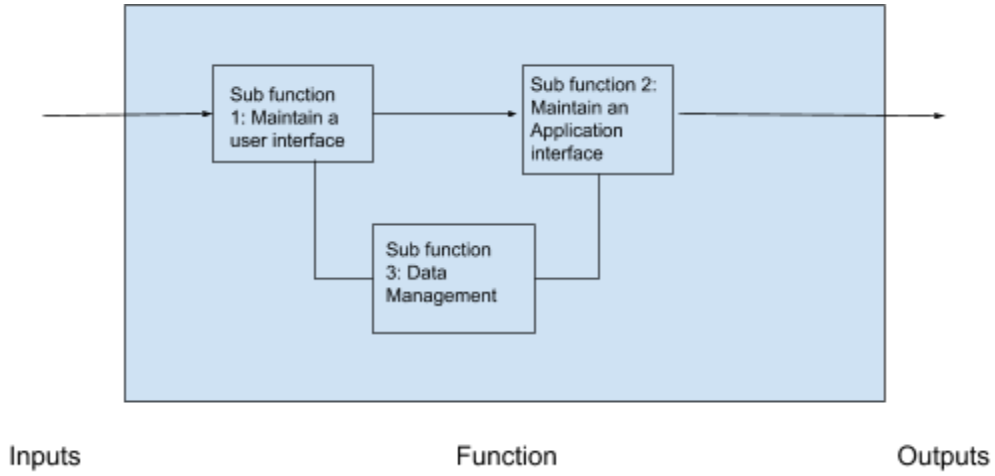
Step 1: Identify the main function of the product, and the inputs and outputs of the product.

Main function	Inputs	Outputs
The main function of a personal computer is to receive, process, store and display data.	Data from keyboard, mouse, and potentially voice input (peripherals) Data received through ports, like USB drives	Sound played out of speakers and headphones Data displayed on screen

Step 2: Identify the sub-functions of the product and create a transparent box model.

Functions	Sub-functions
- Runs an operating system to interface between the user and the microprocessor	- Processor management - Device Management - Receive inputs from user - Data processing - Display output
- Runs software applications designed for specific work or play activities	- Maintain an Application Interface - Display processed data - API to allow applications to use OS functions

- Data Management	- Memory management - Storage Management - Can store data and retrieve stored data



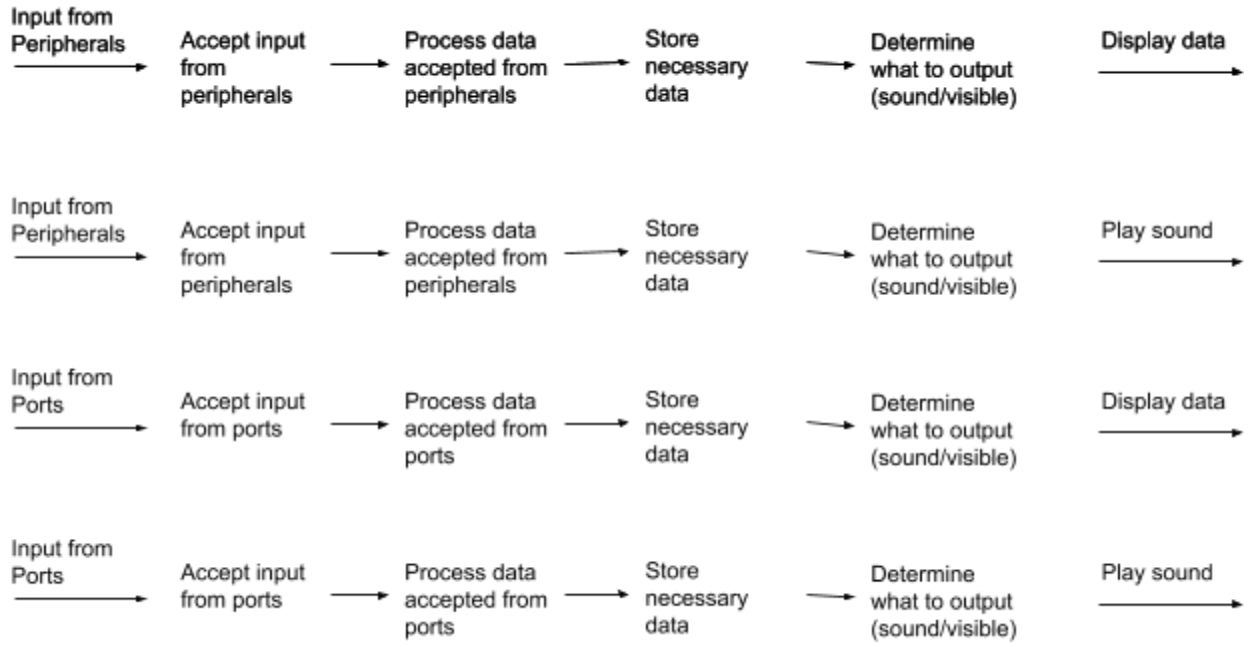
Step 3: Draw the system boundary.

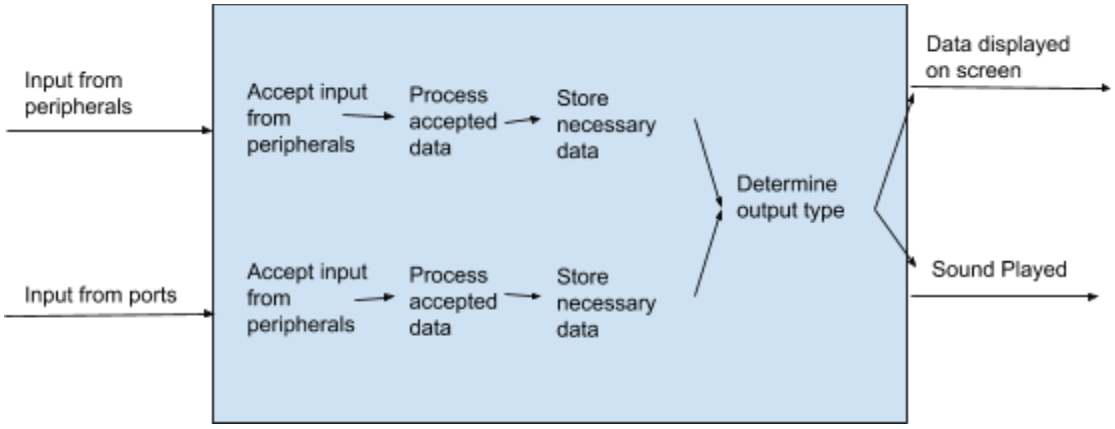
Step 4: Identify the subsystems and components needed to perform the sub-functions

System	Subsystems	Components
Personal Computer	CPU/Motherboard	- ALU - Control Unit - Registers
	RAM	- Circuit Board - Clock - Memory Banks - SPD chip - Burst Counter
	Input/Output	- Keyboard - Mouse

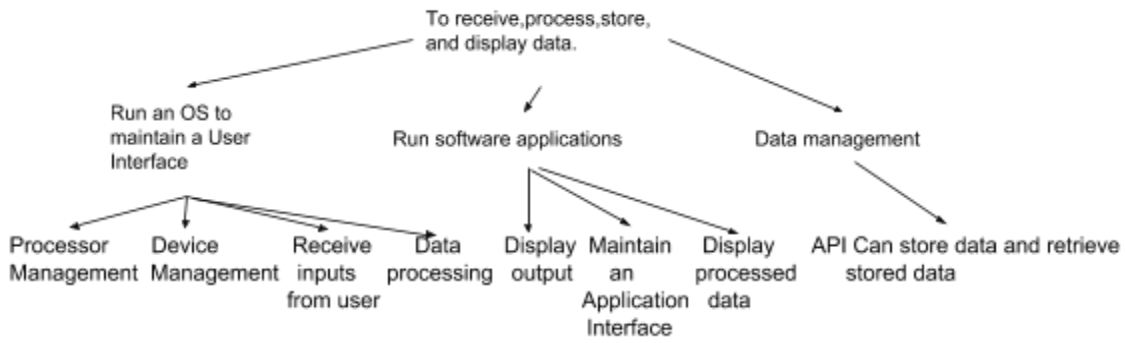
		- GUI/Display Screen - Speakers - Headphone jack

Step 5: Identify the material, energy, and information flows that go into creating the components in the product.





Step 6: Create the FS diagram.



SP3: Describe the differences between the FAST diagram and the Function Structure.

Step 1: Describe the differences.

A FAST diagram shows how the functions of a product are related to the subsystems of a product, and it is useful in understanding how existing products works. A FS diagram is a pure functional representation of a product. The FS diagram is different from the FAST diagram in that it shows only what a product will do, where the FAST diagram also shows how the product will perform its functions.

Step 4: Check your work.

I am confident that all my work is correct.

Step 5: Learn and Generalize.

We can use FAST and Function Structure diagrams to breakdown the functions that products perform. FAST diagrams show how the functions of a product and the subsystems of the product are related, while a FS diagram shows a purely functional representation of the product.

2. Conceptual Design for an Indoor Mobile Robot

Design a mobile robot capable of moving indoors, climbing stairs, and performing useful tasks like cleaning. Proceed as follows: First, using a structured process, develop 4-6 alternative design concepts. Then, using an appropriate utility function, assess and compare these designs to select the “best” alternative for further development

Step 1: Define the real problem.

SP1: Develop 4-6 alternative design concepts for an Indoor Mobile Robot.

SP2: Develop a utility function to assess these designs.

SP3: Use the utility function to select the “best” alternative for further development.

Step 2: Plan how to solve the problem.

Assumptions: I am a manager at a company looking to develop an Indoor Mobile Robot. I need to perform a conceptual design of the product so my team understands what the product will perform and what materials will be used.

Available Information: The PD&D book, lecture notes from class, and information on similar products on the internet.

SP1: Develop 4-6 alternative design concepts for an Indoor Mobile Robot.

Step 1: Establish customer needs and technical metrics using a HOQ.

Step 2: Identify the main function of the product, i.e. the Intent.

Step 3: Identify related products, and reverse engineer one of them using FAST.

Step 4: Create an abstract functional representation of the product, i.e. the FS.

Step 5: (i): for each subfunction develop alternative solution principles

(ii): organize the solution principles into a morphological matrix

Step 6: Develop 4-6 alternative concept designs for the product based on matrix combinations.

SP2: Develop a utility function to assess these designs.

Step 1: Organize the selection criteria as a hierarchy.

Step 2: At each level of the hierarchy assign relative weights for each selection criteria.

Step 3: At each level, compute the absolute weight for the selection criteria.

SP3: Use the utility function to select the “best” alternative for further development.

Step 1: Compute the cumulative utility (CU) for each concept based on the weights assigned for each selection criteria.

Step 2: Select the concept with the highest CU.

Step 3: Execution of the plan.

SP1: Develop 4-6 alternative design concepts for an Indoor Mobile Robot.

Step 1: Establish customer needs and technical metrics using a HOQ.

Need	Importance	No.
Able to move through rooms	10	1
Can sense walls and other objects	10	2
Can clean floors/other surfaces	9	3
Can be recharged	10	4
Easy to use	7	5
Can be programmed wirelessly	5	6

Technical Metrics	Corresponding Needs
Movement speed	1
Able to turn	1,2,3
Suction power	3,5

Cliff Sensors	1,2,3
Object sensors	1,2,3
Room mapping capabilities	2,5,6
WiFi connectivity	5,6
Charging contacts	4

Positive Correlation: +
Negative Correlation: -
No Correlation:

	Movement speed	Able to turn	Suction power	Cliff sensors	Object Sensors	Room mapping capabilities	WiFi connectivity	Charging Contacts
Able to move through rooms	+	+		+	+			
Can sense walls and other objects	-	+		+	+	+		
Can clean floors/other surfaces		+	+	+	+			
Can be recharged								+
Easy to use			+			+	+	
Can be programmed						+	+	

wirelessly								

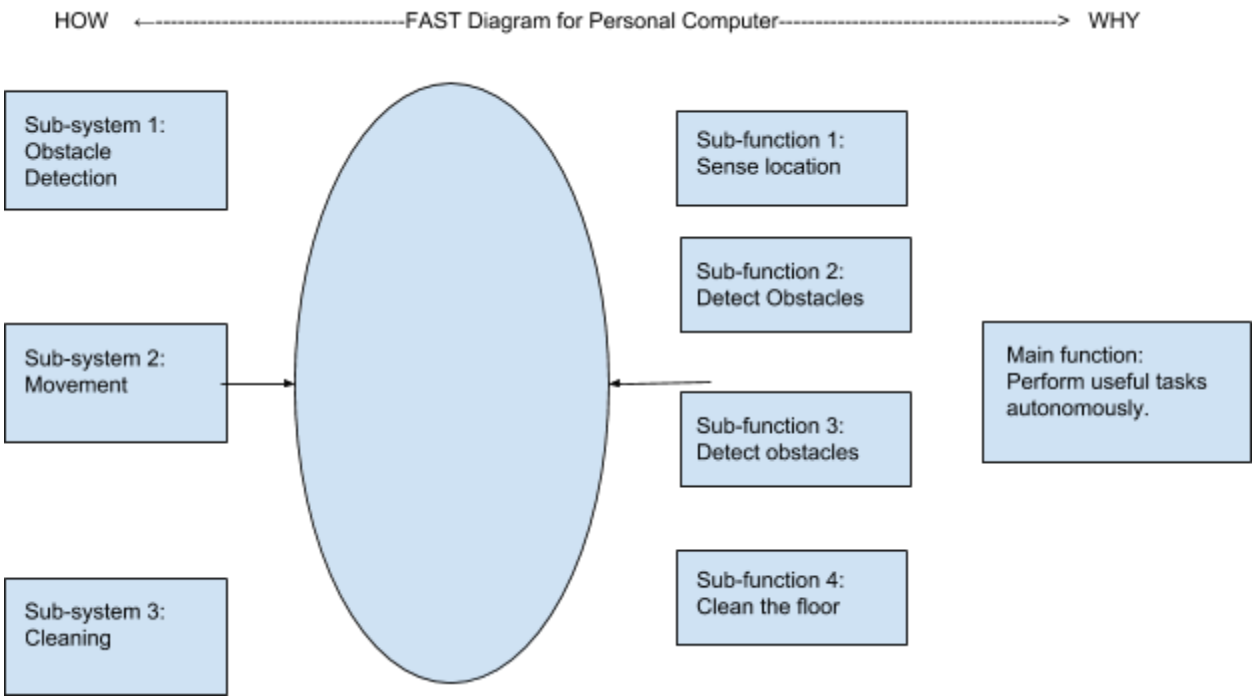
Positive Correlation: +
Negative Correlation: -
No Correlation:

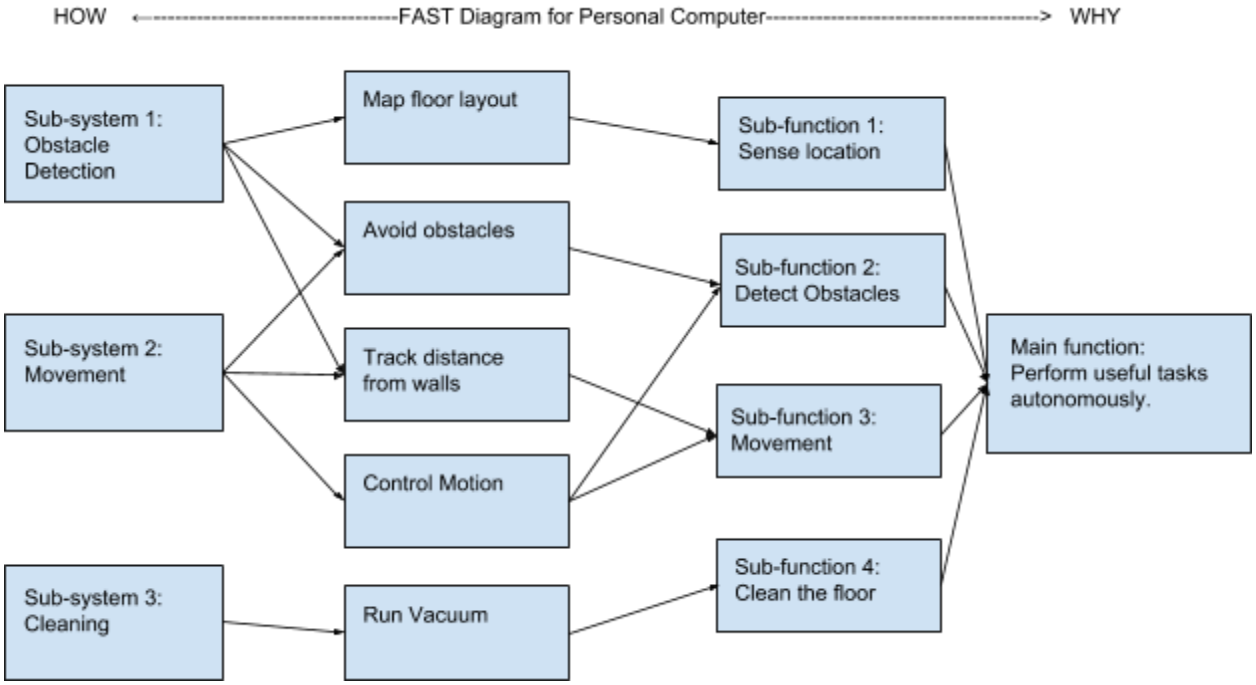
	Movement speed	Able to turn	Suction power	Cliff sensors	Object Sensors	Room mapping capabilities	WiFi connectivity	Charging Contacts
Movement speed	+	-				+		
Able to turn		+				+		
Suction power			+					
Cliff Sensors				+	+	+		
Object sensors					+	+		
Room mapping capabilities						+		
WiFi connectivity							+	
Charging contacts								+

Step 2: Identify the main function of the product, i.e. the Intent.
The main function of an indoor robot is to perform some useful tasks autonomously.
Step 3: Identify related products, and reverse engineer one of them using FAST.
I will reverse engineer the roomba by iRobot.

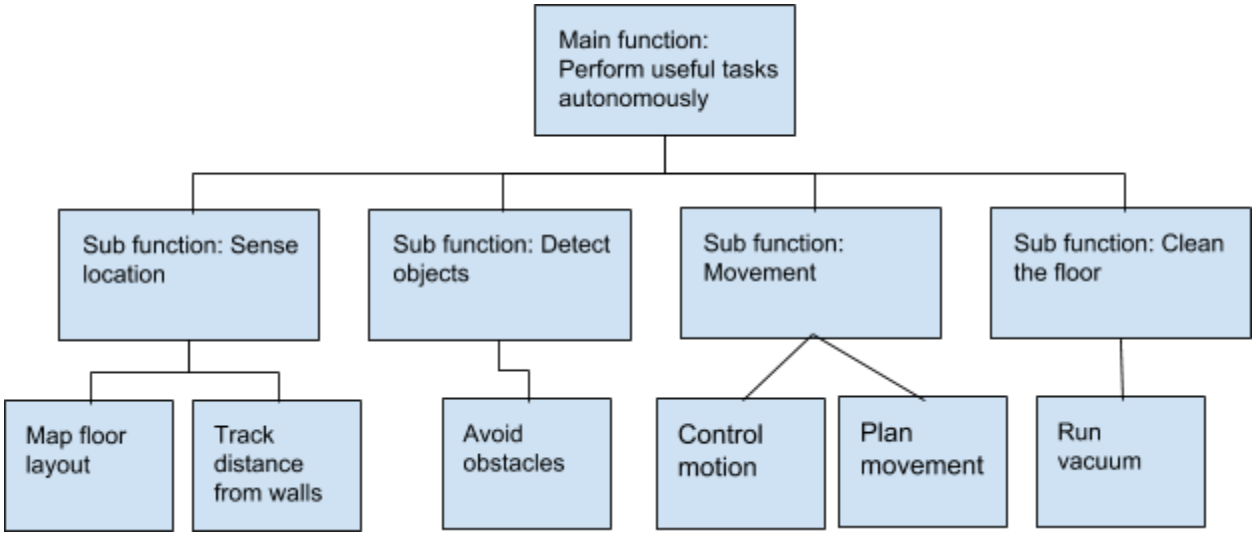
Functions	Subfunctions
Sense location	- Map floor layout - Track distance from walls
Detect obstacles	- Avoid obstacles
Movement	- Control motion - Plan Movement
Clean the floor	- Run vacuum

Subsystems	Components
Obstacle Detection	- Wall sensor - Object sensor - Cliff sensor - Infrared Receiver - Bumper
Movement	- Motors powering side and front wheels - Microprocessor - Rotation Axle
Cleaning	- Spinning side brush - Agitator - Vacuum - Dirt bin - Dirt sensors





Step 4: Create an abstract functional representation of the product, i.e. the FS.



Step 5: (i): for each subfunction develop alternative solution principles
(ii): organize the solution principles into a morphological matrix

	SP1	SP2	SP3
SF1: Sense location	Vision (camera)	Sonar	Infrared
SF2: Detect obstacles	Vision (camera)	Sonar	Infrared
SF3: Movement	Wheels	Legs	Air-cushion
SF4: Clean the floor	Suction vacuum	Brush	Water

Step 6: Develop 4-6 alternative concept designs for the product based on matrix combinations.

Concept 1: We use infrared technology to sense the robot's location within a room, sonar to detect nearby objects, move the robot using wheels, and clean the floor with a suction vacuum.

Concept 2: We use a camera to sense the robot's location within a room, infrared technology to detect nearby objects, move the robot using wheels, and use a suction vacuum to clean the floor.

Concept 3: We use a camera to sense the robot's location within a room, a camera to detect nearby objects, move the robot using wheels, and use a suction vacuum to clean the floor.

Concept 4: We use sonar to sense the robot's location within a room, infrared technology to detect nearby objects, move the robot using an air-cushion, and use a brush to clean the floor.

Concept 5: We use a sonar to sense the robot's location within a room, a camera to detect nearby objects, move the robot using legs, and use water to clean the floor.

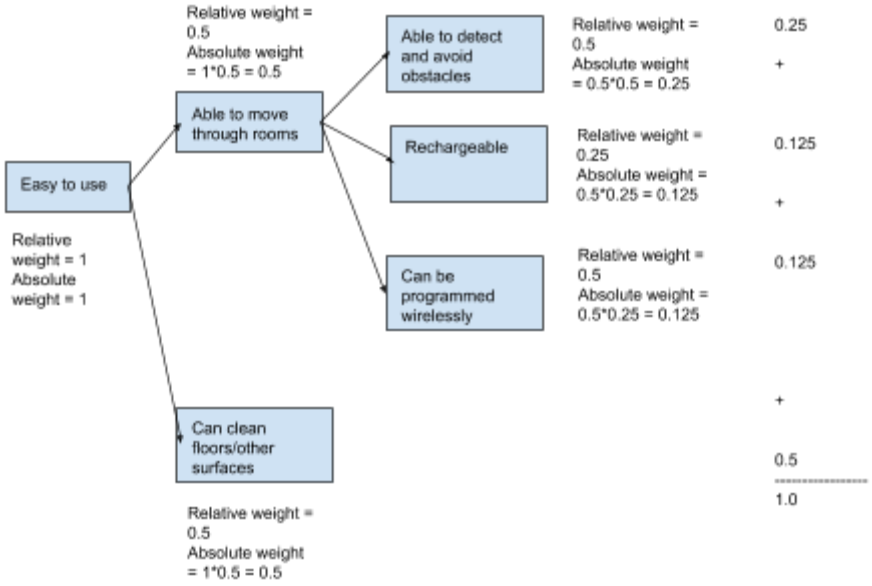
Concept 6: We use a infrared technology to sense the robot's location within a room, a camera to detect nearby objects, move the robot using legs, and use a brush to clean the floor.

SP2: Develop a utility function to assess these designs.

Step 1: Organize the selection criteria as a hierarchy.

Step 2: At each level of the hierarchy assign relative weights for each selection criteria.

Step 3: At each level, compute the absolute weight for the selection criteria.



SP3: Use the utility function to select the "best" alternative for further development.

Step 1: Compute the cumulative utility (CU) for each concept based on the weights assigned for each selection criteria.

Selection Criteria	Absolute Weight	Concept 1 Rating | Utility	Concept 2 Rating | Utility	Concept 3 Rating | Utility	Concept 4 Rating | Utility	Concept 5 Rating | Utility	Concept 6 Rating | Utility
Can sense walls and other objects	0.25	4 | 1	5 | 1.25	4 | 1	4 | 1	3 | 0.75	4 | 1
Can clean floors/other surfaces	0.5	5 | 2.5	5 | 2.5	5 | 2.5	3 | 1.5	2 | 1	2 | 1
Can be recharged	0.125	4 | 0.5	4 | 0.5	4 | 0.5	4 | 0.5	4 | 0.5	4 | 0.5

Can be programmed wirelessly	0.125	4 | 0.5	4 | 0.5	4 | 0.5	4 | 0.5	4 | 0.5	4 | 0.5
Summation	1.0	4.5	4.75	4.5	3.5	2.75	3

Step 2: Select the concept with the highest CU.

Concept 2 has the highest Cumulative Utility at 4.75. In concept 2 we use a camera to sense the robot's location within a room, infrared technology to detect nearby objects, move the robot using wheels, and use a suction vacuum to clean the floor.

Step 4: Check your work.

I am confident that all my work is correct.

Step 5: Learn and Generalize.

I learned how to develop concepts for the design of a new product based on the customer needs for the product, and how similar products are designed. No product appears out of nowhere, and this process allows us to design new ones based on similar products, altering a few variables to produce a better product.

3. Conceptual design for team project.

Defining the problem more in depth:

How will our product be designed and applied to the needs of the customers?

Decide on whether Snooze should fund the research team and produce the smart pillow

i. Select the decision that would maximize EMV without exceeding the total capital budget constraint

Create a "table lookup"

ii. Determine which projects to select by maximizing cumulative expected profit without exceeding the total capital budget constraint
    1. Calculate the Return On Investment (ROI) of each project

Calculate the cash left in the capital budget after making project selections

iii. Recommend management plans to utilize cash

Plan a solution:

- Assumptions:
  - I am an analyst hired to decide which projects the company will pursue and to maximize the company's cumulative Expected Monetary Value (EMV)
  - The Research & Development Program has a total price tag of $30 M
  - Price of technology purchases alone: $27.86 per pillow
    - 3-axis gyroscope technology that tracks sleeping motion

        - Actigraphy Motion Biosensor Sheet to track
        - Microphone
    - Total Pricing of pillow including polyester and cooling gel: $34.87 per pillow
    - Assembling Cost: $5 per pillow
    - There is a 75% chance the R&D will be successful and find the most accurate way to track sleep, one equivalent to the polysomnography technology
        - If the R&D team finds a surpassing and cost efficient technology for the pillow, and develops the product with a different factory, there will be a total of $100M in Revenue
    - There is a 60% chance the product development will be successful while producing in-house
        - If the product development is successful there will be a profit of 150M
            - [(5,000,000 (pillows) x $80 (price)] - [(5,000,000 (pillows) x $39.87 (cost)] = $151,650,000 or 150M after equipment & machinery

➢ Information Needed:
- The Probability of success of the R&D
- The Probability of success of the Product Development (PD) effort
- Profit of each Project
- Budget

1. Develop a comprehensive project plan of your project indicating the roles and responsibilities of each group member.
2. Create a House of Quality
3. Create Aggregate Project Plan
    i. Identify costs to each potential project
    ii. Create a decision analysis to estimate EMV
        1. Identify Building Blocks
        2. Create Influence Diagram
        3. Create Decision tree using the Influence Diagram
        4. Fold back decision tree to estimate value
        5. Create a Sensitivity Analysis
    iii. Create a Table look-up
        1. Introduce a project selection decision variable
        2. Calculate the cumulative EMV

4. Identify existing products that are similar to your product idea and reverse engineer them using FAST.
5. Apply the conceptual design process to create several alternative concepts for your product idea.

Execute the plan:

1. Project plan:
    a.

Sunday, Nov. 12th	Create a google document and share it with the group. Copy and paste the requirements for the next phase and start familiarizing ourselves with the questions. Begin researching.
Monday, Nov. 13th	Meet with group at 7:30pm to discuss the project and begin working on our report as a group. Assigning members to different parts and asking questions when needed.
Tuesday, Nov. 14th	Create an organized binder filled with our work, starting from the beginning of our idea.
Wednesday, Nov. 15th	Meet with the TA at 2pm to go over our project.
Friday, Nov. 17th	Discuss phase III and determine a good time to meet as a group.

    b. Roles of each team member
        i. Vinshaan Nguyen- Conceptual design planner, engineer
        ii. Dan Vo- Creator of our project's market analysis and business strategy
        iii. Manzanita Griffin- Organizer of paperwork, focused on EMV, COO
        iv. Kaitlyn Martinez- Business spokeswoman and utility functional expert
        v. Kevin Chen- Budgeting expert, works with product dissection, CFO
        vi. Diego Garcia- Generator of HOQ and technical matrix
        vii. Austin Wisherop- Project plan coordinator, CEO and President
        viii. Ethan Cox- Creator of solution principles and the morphological matrix

2. Make a structured and prioritized list of customer needs for bed essentials based on market research. Rate these needs on a 1-10 scale of importance.
    a. Successfully Awakens User - 10/10
    b. Sleep Comfortability is Unwavered - 7/10
    c. Device isn't distracting of its goal - 4/10
    d. Easy to maintain - 6/10
    e. Tracks sleep habits - 5/10

    Make a list of technical metrics and assess the importance of each metric on a 1-10 scale.
    a. Material 8/10
    b. Vibration strength and effectiveness 8/10
    c. Screen 4/10
    d. Electronic connectivity 4/10
    e. Battery life 7/10
    f. Durability 9/10
    g. Electrical Component's Weight - 4/10
    h. Electrical Component's Size - 7/10

    Correlate customer needs and technical metrics using a scale.
    High positive - ●
    Medium positive - ○
    Medium negative - ◇
    High negative - ◆
    No correlation -
    Minimize - ▼
    Maximize - ▲
    Target - ✖

	Waking up	Sleep comfortably	Lack of distraction	Easy maintenance	Track sleep habits
Material (✖)		●		○	
Vibration strength and effectiveness (✖)	●	◇		◇	
Screen			◆	◆	

component (✖)					
Connectivity (bluetooth) (✖)			◇	◇	●
Battery life (▲)				●	
Durability (▲)		○		●	
Vitals tracking (✖)	●	●	●	●	●
Electrical Component's Weight (▼)		○			
Electrical Component's Size (▼)		○	○		

Correlate just the technical metrics between each other and place half of that matrix on the top of the diagram made in step 9.

	Material	Vibration strength	Screen component	Connectivity (bluetooth)	Battery	Durability	Vitals tracking	Electrical Component's Weight	Electrical Component's Size
Material									
Vibration strength	◇								
Screen component									
Connectivity			○						

Battery			●						
Durability					●				
Vitals tracking			●	●	◇				
Electrical Component's Weight									
Electrical Component's Size		◇				◇		●	

Waking up		●					●		
Sleep comfortably	●	◇				○	●	○	●
Lack of distraction			◆	◇			●		●
Easy maintenance	○	◇	◆	◇	●	●	●		
Track sleep habits				●			●		

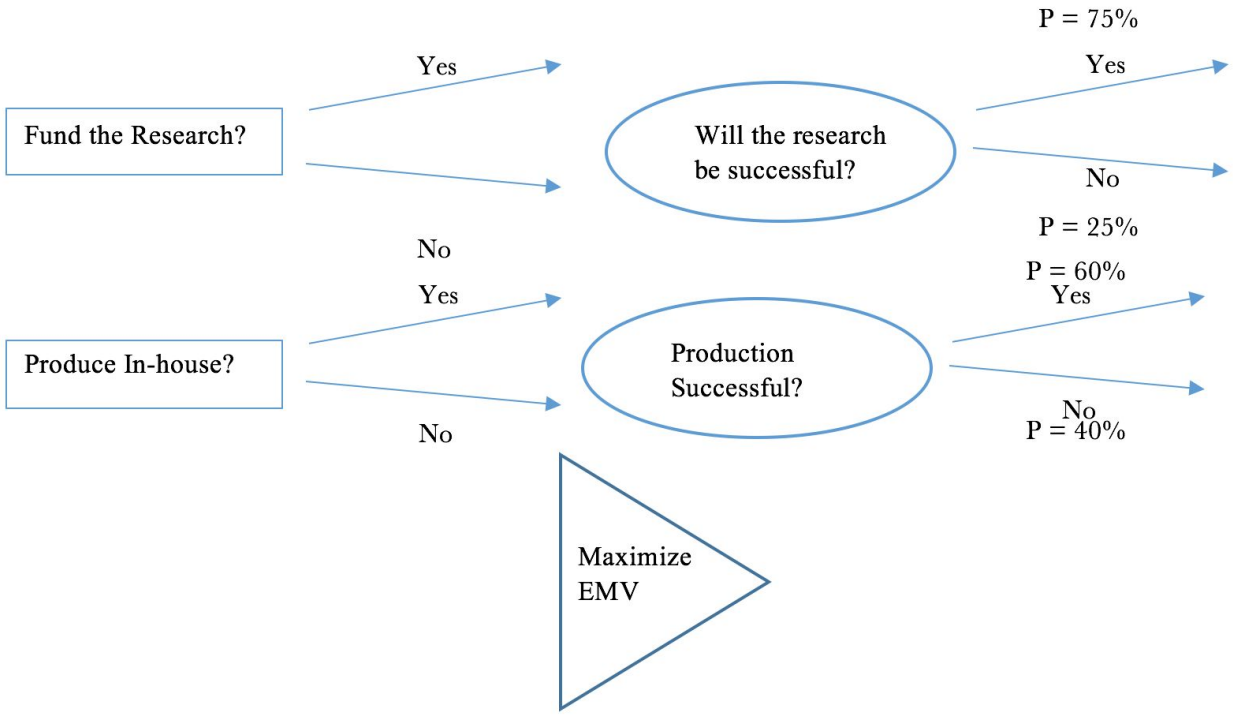
Assess a set of related competing products from the viewpoint of the customer, viewpoint of the engineer, and the viewpoint of the engineering unit of measurement for technical benchmarking.

Product:	Customers:	Engineers:	Engineering Unit:
Smart Shaker (iLuv)	Shaker not strong enough for deaf, power cord too short, good for traveling, multiple vibration settings, app isn't very useful.	Shake and/or alarm for waking options, connects via bluetooth to phone, multiple alarm options, long battery life, small device	• 0.15 lbs • 3.5" x 7.9" x 3.5" • Micro USB cable • iOS/Android compatibility • Up to a month of charge
Pillow by Neybox	Compares sleep cycles, offers sleep recommendations, records what noises influence sleep cycle, optimal wakeup time option.	Sleep tracking and analysis, Sleep sound recordings, alarm clock, sleep recommendations,	• Phone app (only iOS compatible) • Size = User's Phone Dimensions

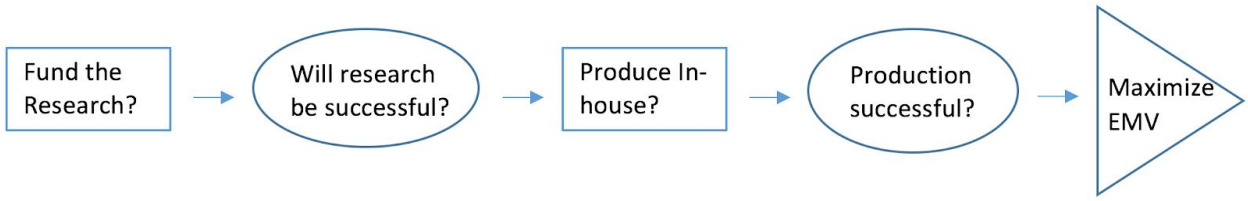
Set customer needs and technical metric targets for your project.

Customer Needs:	*Technical Metrics Target:*
Waking up	Vibration strength and effectiveness
Sleeping comfortably	Soft material used, Small Electrical Components
Easy to maintain	Removable clock
Reliable	Battery life, Electronic Connectivity

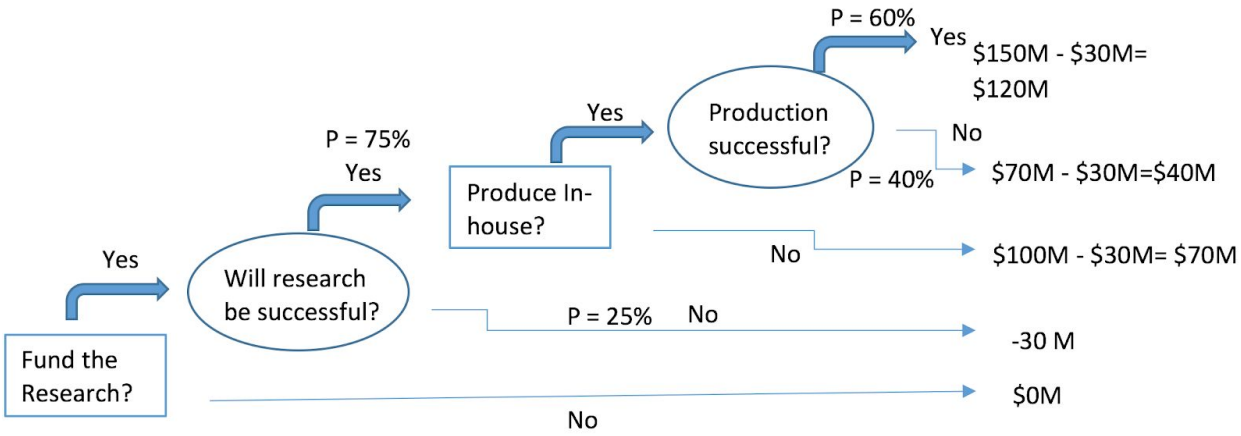
3. Identify the Building Blocks



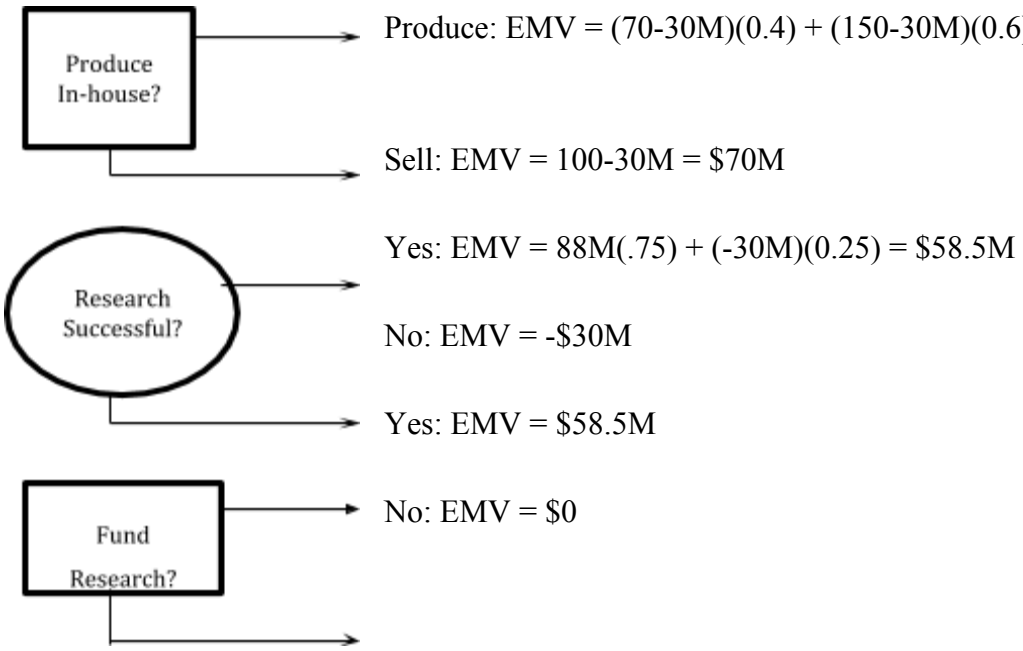
Identify the Influence Diagram (ID): chronological relationship between the building blocks



Create the Decision Tree (DT) with all relevant information (cost, revenues...etc)



Fold Back the Decision Tree to calculate payoffs associated with each decision.



By computing the expected monetary value of funding the research and development of our product, we can come to the decision to invest in our own product. With a 75% success rate of research to develop our product, the initial $30M investment would have to yield a $45M payout to break even, but in our case the payout exceeds this threshold allowing us to make the easy decision to fund the research of our product.

Aggregate Project Plan:

Based on the 6 different variations we can use here is what investing in a combination of each one would look like.

*0 for no investment, 1 for invest

R&D	SP1	SP2	SP3	SP4	SP5	SP6	R&D	SP1	SP2	SP3	SP4	SP5	SP6	Total investment in M
0	0	0	0	0	0	0	100	30	30	30	30	30	30	0
0	0	0	0	0	0	1	100	30	30	30	30	30	30	30
0	0	0	0	0	1	0	100	30	30	30	30	30	30	30
0	0	0	0	0	1	1	100	30	30	30	30	30	30	60

0	0	0	0	1	0	0	100	30	30	30	30	30	30	30
0	0	0	0	1	0	1	100	30	30	30	30	30	30	60
0	0	0	0	1	1	0	100	30	30	30	30	30	30	60
0	0	0	0	1	1	1	100	30	30	30	30	30	30	90
0	0	0	1	0	0	0	100	30	30	30	30	30	30	30
0	0	0	1	0	0	1	100	30	30	30	30	30	30	60
0	0	0	1	0	1	0	100	30	30	30	30	30	30	60
0	0	0	1	0	1	1	100	30	30	30	30	30	30	90
0	0	0	1	1	0	0	100	30	30	30	30	30	30	60
0	0	0	1	1	0	1	100	30	30	30	30	30	30	90
0	0	0	1	1	1	0	100	30	30	30	30	30	30	90
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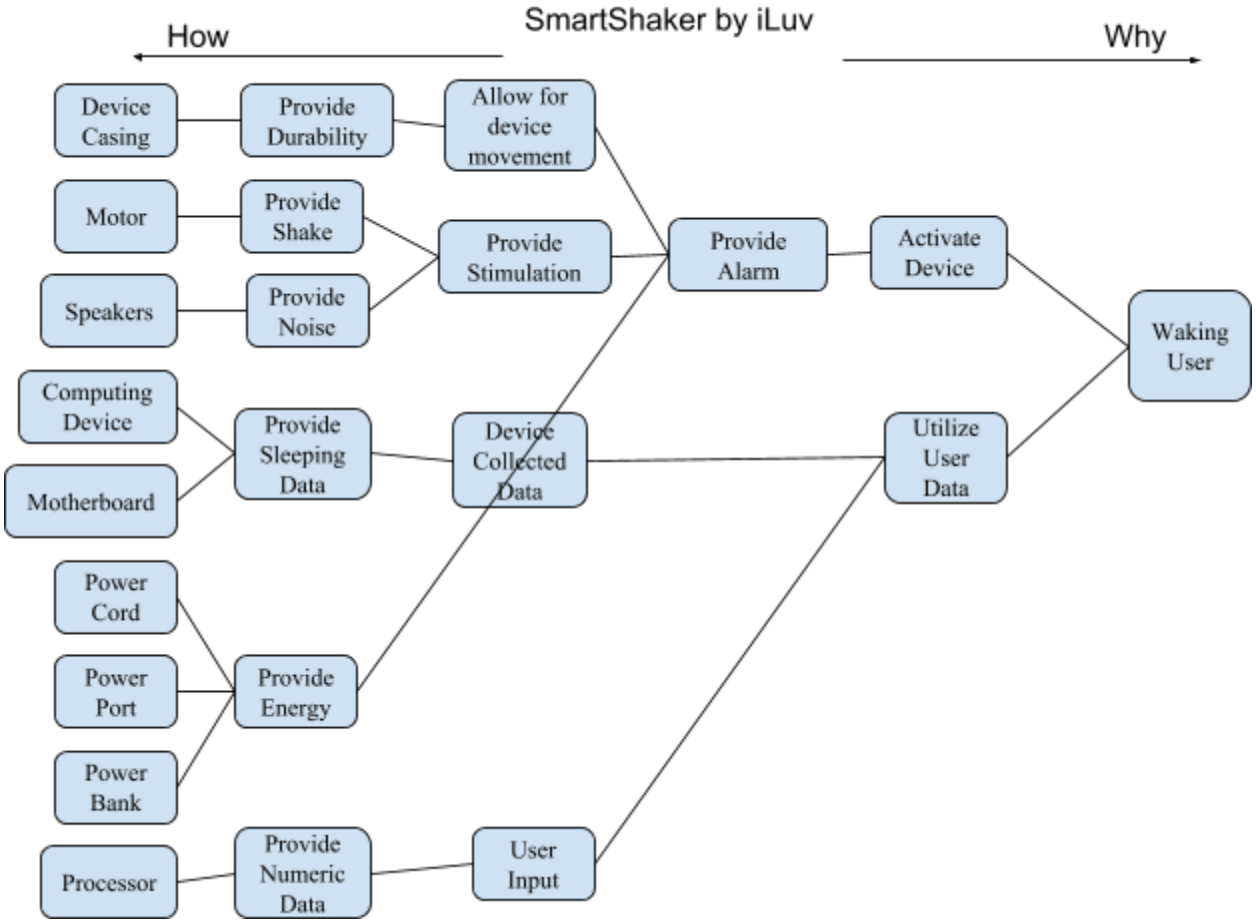
1	1	1	1	1	1	1	100	30	30	30	30	30	30	280

4. [1] Smart Shaker by iLuv
    a. How does the product work?
        i. This small round alarm clock provides two waking options (Alarm and Shake). The device can be placed either on the bed or under a pillow for proper use. Connect wirelessly via bluetooth to a smart device to set-up the desired alarm/shake combo and time.

    Make a list of important subsystems and components
    a. Subsystems
        i. Device casing - protects hardware
        ii. Motor - shakes entire device
        iii. Power Bank - powers technical components in device
        iv. Computing Device - computes information that device records
        v. Speakers - makes noise for alarm
    b. Components
        i. Plastic shell
        ii. Power Cord
        iii. Power Port
        iv. Motherboard
        v. Processor

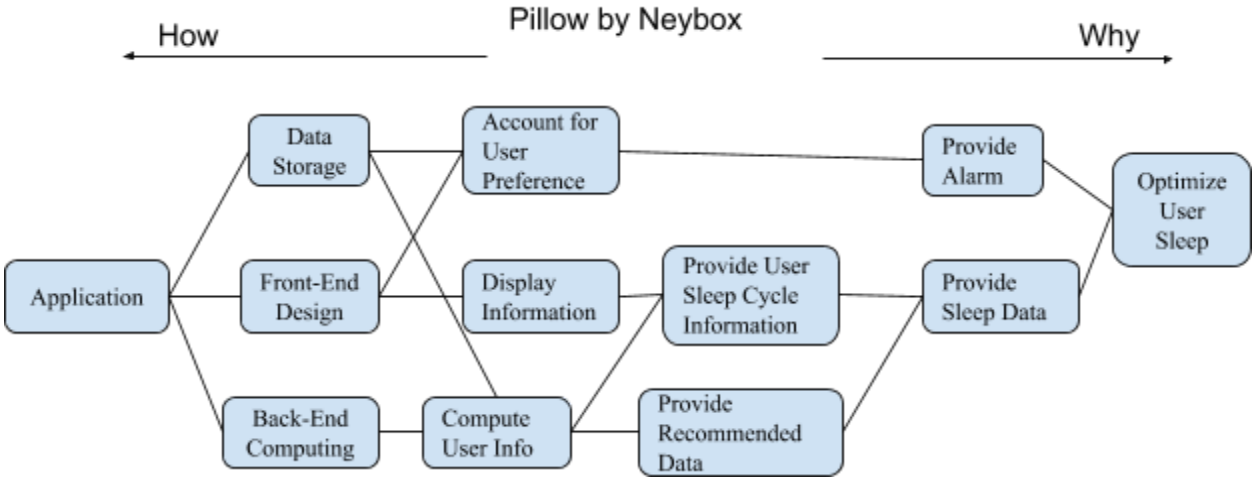


[2] Pillow by Neybox

a. How does the product work?
    i. This app run's on the user's apple device and can measure sleep cycles, provide sleeping recommendations, record sleeping audio (for further sleep analysis), and provide an alarm clock to wake up at a specific time or at recommended optimal awakening time. The user places the phone with the app running on the bed as he/she sleeps. Additionally, a smartwatch can be added to analyze heart rate and even more precise information about sleep movement.

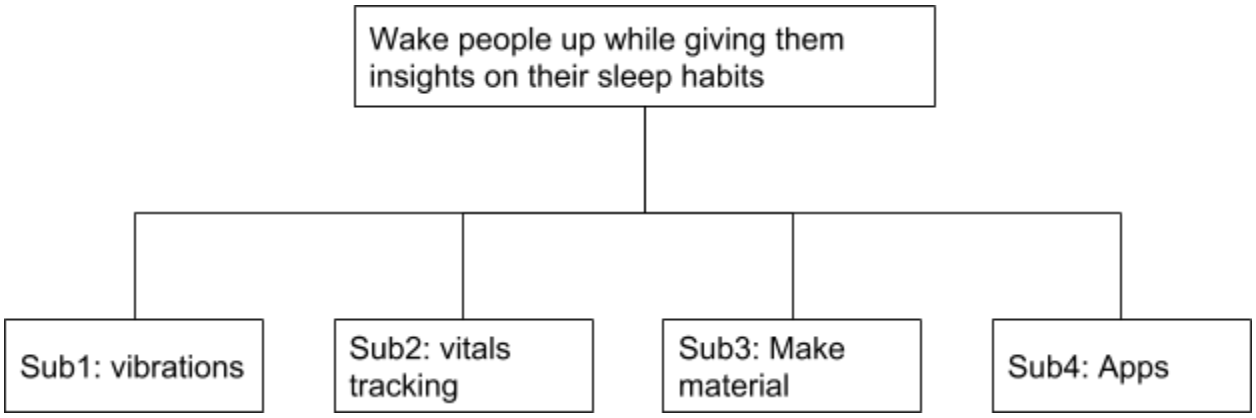
Make a list of important subsystems and components

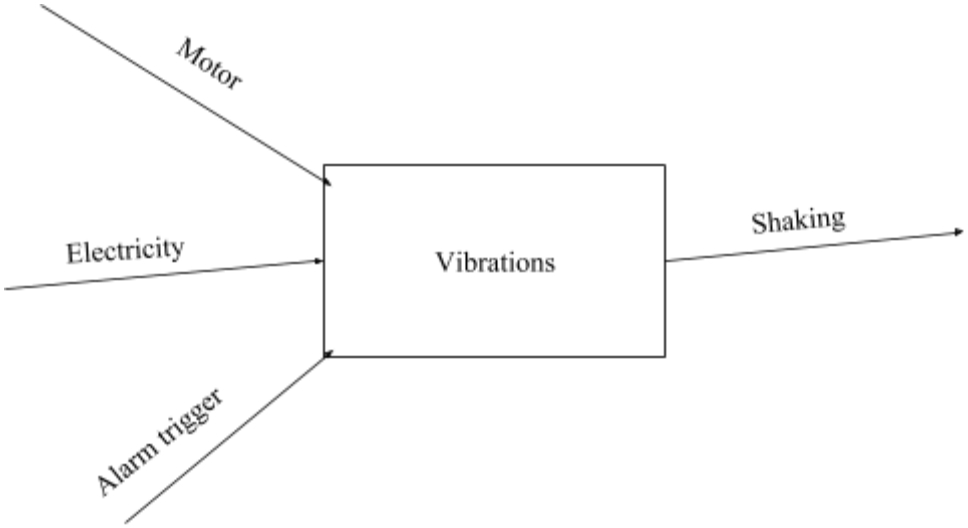
a. Subsystems
    i. Application - provides primary user interface
b. Components
    i. Data Storage
    ii. Front-End design
    iii. Back-End computing

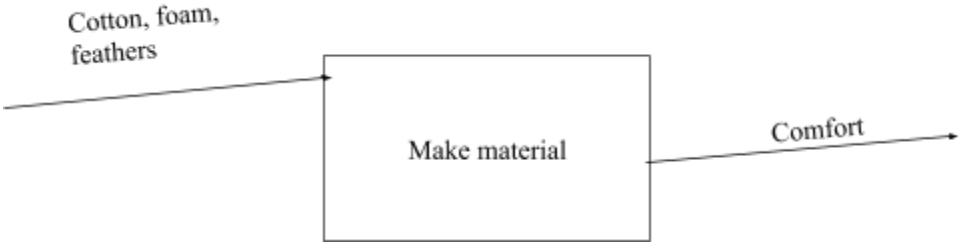


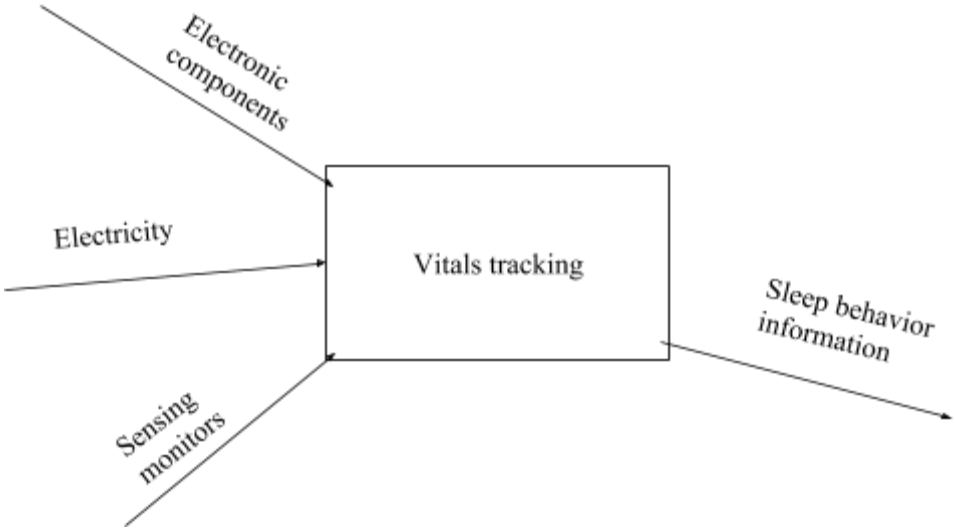
After reverse engineering two specific but relevant products, we can see the exact elements that allow our competitors to excel in revolutionizing sleep. By combining and improving upon elements outlined, we can better develop our product and ultimately outperform the competition.

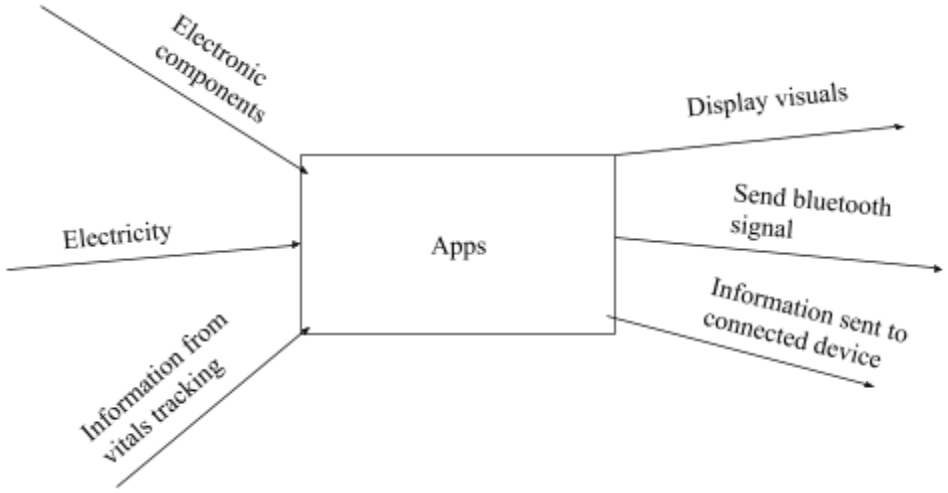
5. Function structure diagram:




Motor
Electricity
Vibrations
Shaking
Alarm trigger


Cotton, foam,
feathers
Make material
Comfort


Electronic
components
Electricity
Vitals tracking
Sleep behavior
information
Sensing
monitors



Morphological Matrix:

Solution Principles (right) ---------- Subfunctions (down)	SP1	SP2	SP3	SP4	SP5	SP6
SF1: Vibration	Motor ●○◆▲⬡ ⭑					
SF2:Vital Tracking	Actigraphy ●○⬡	Polysomnography ◆▲	Skin temp, perspiration ⭑	Heart Rate and Rhythm	# of sleep positions/ time in each	Breathing patterns
SF3: Material	Cotton ○	Down ●	Memory Foam ◆⭑	Gel ▲	Latex	Polyester ⬡
SF4: Applications	Mobile Apps ●○◆⬡⭑	For a device we create	Web apps	iPad/other tablets ▲	Smart Watch	FitBit/other wrist trackers

Conceptual Designs	● (1)	○(2)	◆ (3)	▲(4)	⬡ (5)	⭑(6)

Conceptual Designs:

Concept 1:

We use a motor to cause the pillow to vibrate, track the user's vitals using actigraphy, use down as the material, and develop mobile apps for the user to see data about their sleep habits. Using down as the pillow material raises the price of the pillow since down is a more expensive material, but all other aspects of the pillow are well developed and relatively cheap. Actigraphy technology is able to measure how long the user is asleep, but not the stages (REM, deep, etc) of that sleep. This concept works well for people who want high quality pillow that works well as an alarm clock, but aren't concerned with the pillow's sleep tracking ability.

Concept 2:

We use a motor to cause the pillow to vibrate, track the user's vitals using actigraphy, use cotton as the material, and develop mobile apps for the user to see data about their sleep habits. This concept would be marketed as a cheaper version of the pillow. Actigraphy technology is well developed and relatively cheap, cotton is one of the cheapest pillow materials, and the other solution principles used cost very little. Developing mobile apps is more beneficial than developing web apps as most people have a smartphone, and people are more likely to use a smartphone app to check their sleep habits than a web app.

Concept 3:

We use a motor to cause the pillow to vibrate, track the user's vitals using polysomnography, use memory foam as the material, and develop mobile apps for the user to see data about their sleep habits. This concept would be marketed as a high quality version of the pillow. Memory foam is a high quality material to make the pillow with, and polysomnography is the gold standard of sleep tracking technology. The issue with this concept would be implementing the polysomnography technology as multiple different aspects of the user's sleep have to be tracked. Thus, there would be a high chance of technological failure while developing the pillow.

Concept 4:

We will use a motor to cause the pillow to vibrate, polysomnography to track the user's vitals, gel as the pillow's material, and develop apps that work for both Android and iOS. Some people prefer the comfortness of gel however the material containing the gel would have to be very durable so it doesn't pop and leak all over the user's head and bed.

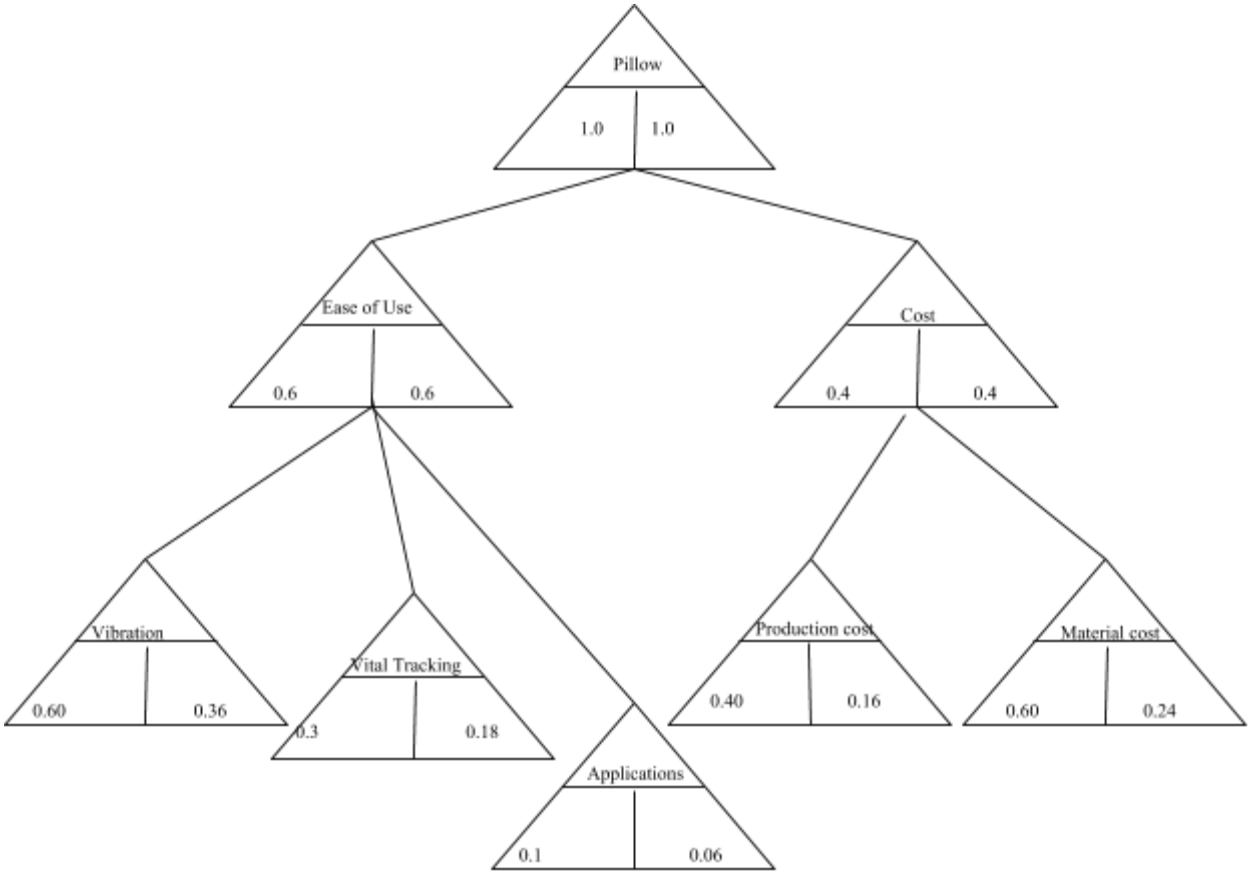
Concept 5:

We will use a motor to cause the pillow to vibrate, actigraphy to track sleeping patterns, polyester for the pillow's material, and mobile applications to track it through phones. This will be another addition to the cheaper model of the pillow. Polyester is one of the standard materials for pillows and actigraphy is well developed and easy to get.

Concept 6:

We will use a motor to cause the pillow to vibrate, skin temp monitor, memory foam as the material, and mobile apps to control/monitor yourself. Through a skin temp monitor, this pillow could have a functional temperature control, controlling the temperature of the pillow in order to provide you warm or cool temperatures for your head. This pillow could be mid to high tier.

Utility Function:



Criteria to evaluate how well our design concepts satisfy the user needs(design objectives) and compare:

Criteria	Absolute Weight	PD1		PD2		PD3		PD4		PD5		PD6	
		Rating	Utility	Rating	Utility	Rating	Utility	Rating	Utility	Rating	Utility	Rating	Utility
Vibration	0.36	5	1.8	4	1.44	3	1.08	2	0.72	3	1.08	2	0.72
Vital Tracking	0.18	4	0.72	5	0.9	4	0.72	1	0.18	4	0.72	2	0.36
Applications	0.06	3	0.18	4	0.24	4	0.24	3	0.18	4	0.24	3	0.18
Production Cost	0.16	3	0.45	3	0.48	4	0.64	3	0.48	5	0.8	4	0.64
Material Cost	0.24	2	0.48	3	0.72	3	0.72	4	0.96	4	0.96	5	1.2
Total	1	CU = 3.63		CU = 3.78		CU = 3.4		CU = 2.52		CU = 3.8		CU = 3.1	

Comparison Summary:

Best design concept and develop it into a product:

Potential design 5 seems like it fits our criteria the best with a cumulative utility value of 3.8. Therefore this concept will be our main one. This concept allows us to enter the market with a cheap product instead of entering it with a higher end one. Because the materials we use are easily available, it will be our primary focus to create a great product with what we have decided to use.

Potential design 2 is our second highest with a CU of 3.78. This will be the second concept to pursue. PD 2 is similar to PD5 in the case that the materials used are easily accessible. The switch is that PD 2 uses cotton instead of polyester so the product will have a fluffier texture when rested upon.

Check you work:

We have checked our work and made sure that it is correct in every aspect.

Learn and generalize:

We have learned that we can use Product Design to choose potential concepts with the six step process.