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12/8/17
TIM 105

Final

1. Planning.

Review the examination questions, below, and then develop a non-trivial task-based plan for completing this final examination:

a) Make a list of the necessary activities/tasks, and draw the design (activity) structure matrix showing the task dependencies.
b) Use Gantt charts to develop a schedule for completing the exam on time with high quality.
c) Keep track of your progress and document when each task is completed.

On completion of the exam, draw conclusions, and develop guidelines to improve your own planning process and implementation in the future.

Step 1: Define the real problem.

SP1: What are the necessary activities/tasks needed to complete the exam and the their dependencies.

SP2: Draw the design structure matrix showing the task dependencies.

SP3: Create a Gantt chart to develop a schedule for completing the exam.

SP4: Track my progress and document when each task is completed.

SP5: When finished, draw conclusions and developed guidelines for improving my planning process.

Step 2: Plan how to solve the problem.

Assumptions: I am starting the exam on Friday 12/8 and will complete it by Monday 12/11. I will be able to spend at least five hours on the exam each day.

What information is available: The PD&D book, class notes, and information on the internet.

SP1: What are the necessary tasks needed to complete the exam.

Step 1: Make a list of the activities/tasks and the dependencies of each task.

SP2: Draw the design structure matrix.

Step 1: Create the design structure matrix.

SP3: Create a Gantt chart.

Step 1: List the time it will take to complete task.

Step 2: Create the Gantt chart.

SP4: Track my progress and document when each task is completed.

Step 1: Create a list of tasks and when they are completed.

SP5: Conclusions and guidelines.

Step 3: Execute the plan.

SP1: What are the necessary tasks needed to complete the exam.

Step 1: Make a list of the activities/tasks and the dependencies of each task.

Task #	Task	Dependencies
A	Problem 1	AxB, AxC, AxD, AxE
B	Problem 2	BxA,
C	Problem 3	CxA,
D	Problem 4	DxA, DxB, DxC
E	Problem 5	ExA,

SP2: Draw the design structure matrix.

Step 1: Create the design structure matrix.

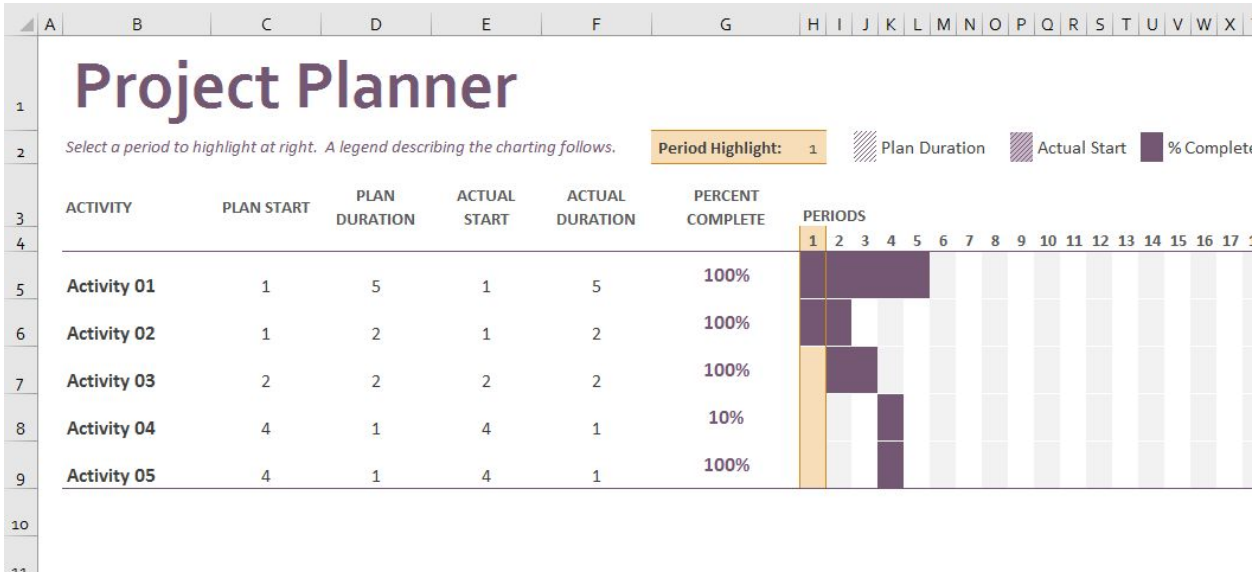
	A	B	C	D	E
A	A	X	X	X	X
B	X	B			
C	X		C		
D	X	X	X	D	
E	X				E

SP3: Create a Gantt chart.

Step 1: List the time it will take to complete task.

Task #	Task	Time to complete
A	Problem 1	1.5 hours, Friday 5:30 - 7:00 pm
B	Problem 2	6 hours, Friday 8:00 - 10:00 pm, Saturday 10am - 2pm
C	Problem 3	3 hours, Saturday 7-10 pm
D	Problem 4	1.5 hours, Sunday 10-11:30 am
E	Problem 5	1 hour, Sunday 12-1 pm

Step 2: Create the Gantt chart.



SP4: Track my progress and document when each task is completed.

Step 1: Create a list of tasks and when they are completed.

Task #	Task	Time When Completed
A	Problem 1	Friday 7:15 pm
B	Problem 2	Saturday: 6 pm
C	Problem 3	Sunday: 10 pm
D	Problem 4	Monday: 11 am
E	Problem 5	Monday 12 am

SP5: Conclusions and guidelines.

1. Always assume each task will take longer than expected to complete.
2. Always assume I will not be able to start on each task exactly when I plan.
3. Make sure I leave extra time to complete the exam if it takes longer than expected.

Step 4: Check your work.

I am confident that all my work is correct.

Step 5: Learn and Generalize.

We can use multiple different types of planning charts to understand how the tasks needed to complete an assignment are related. Based on the relation of these tasks we can plan how to do any assignment. This allows us to use our time more efficiently.

2. Product Development for a Virtual Reality Entertainment System.

a) Provide a written statement of your structured process for generating a feasible design concept for further development. (This process should include steps such as: functional specification, concept generation, and concept selection).
b) Dissect the following products:
   a. Video game console
   b. Virtual reality headset
   c. Video-game motion-tracking sensor
c) Implement your structured process and create a feasible concept for the VR entertainment system based on the functional requirements listed above. Provide a concise explanation of how the selected product concept works.
d) Develop a product platform and product line strategy for the following three market segments:
   i) "serious gamer" users who are almost exclusively interested in high-resolution graphics and a realistic VR experience for playing video games
   ii) "casual" users who are interested in using VR to have new experiences, e.g. travel, meditation, and education
   iii) "professional" users who are interested in using VR for business applications such as designing and prototyping new products.
e) Develop an FMEA of the product line designed for the "serious gamer" user. From your FMEA analysis identify the three most critical failure modes.

Step 1: Define the real problem.

SP1: Create a structured process for generating a feasible design concept of a generic product.

SP2: Dissect a video game console.

SP3: Dissect a virtual reality headset.

SP4: Dissect a video-game motion-tracking sensor.

SP5: Create a feasible concept for a VR entertainment system based on the given sub-functions, and provide a concise explanation of how the product concept works.

SP6: Develop a product platform and three product lines for different market segments.

SP7: Develop an FMEA of the product line for "serious gamers" and identify the three most critical failure modes.

Step 2: Plan how to solve the problem.

Assumptions: A Virtual Reality Entertainment System can be created. I am an engineer working at Microsoft in 2017 looking to develop a new VR entertainment system.

Available information: The PD&D book, class notes, information on the internet about how the products that need to be dissected work, and work done on the midterm that relates to this problem.

SP1: Create a structured process for generating a feasible design concept of a generic product.

-- what are the necessary steps to design concepts for a new product

-- look at class notes

SP2: Dissect a video game console.

-- I will dissect the Xbox 1

-- Use the FAST structure to dissect this product.

SP3: Dissect a virtual reality headset.

-- I will dissect the Oculus Rift using the FAST structure.

SP4: Dissect a video-game motion-tracking sensor.

-- I will dissect the Microsoft Kinect using the FAST structure.

SP5: Create a feasible concept for a VR entertainment system based on the given sub-functions, and provide a concise explanation of how the product concept works.

-- apply the structure stated above to the new product

SP6: Develop a product platform and three product lines for different market segments.

-- identify the main and supporting technologies of the product.

-- create three product lines based on the identified technologies.

SP7: Develop an FMEA of the product line for “serious gamers” and identify the three most critical failure modes.

-- create a FAST diagram for the product design for “serious gamers”

-- identify the potential failure modes for each subsystem of the product.

-- calculate the RPN for each failure mode and decide whether action should be taken to fix these issues

Step 3: Execute the plan.

SP1: Create a structured process for generating a feasible design concept of a generic product.

Step 1: Establish customer needs and technical metrics/specifications for the new products using the HOQ.

Step 2: Identify the main function of the product (i.e. the product intent).

Step 3: Identify one or more related products and dissect them using FAST (will be done in SP2-SP4).

Step 4: Create an abstract representation of the new (intended) product, called the Function Structure.

Step 5: i) for each sub-function, generate alternative solution principles for realizing that sub-function.

ii) Create a Morphological Matrix.

Step 6: Generate 4-6 alternative concepts for the new product design.

Step 7: Identify a set of selection criteria to assess/compare these alternatives, and use these selection criteria to construct a Utility Function.

Step 8: Use the utility function to compare the alternatives generated in Step 6, and select one concept for further development.

SP2: Dissect a video game console.

Step 1: Understand how the Xbox 1 works by researching online.

Step 2: Make a structured list of the important subsystems and components that are relevant.

System	Subsystems	Components
Xbox 1	Kernel (OS)	CPU
	Data reader/storage	DDR3 RAM
	Video signal	ESRAM
	Graphics processor	GPU
	Audio processing	Blu-ray drive
	Input System	Hard drive
	Internet Connectivity	USB 3.0 super speed ports
	Motion Sensing	HDMI ports
		S/PDIF optical audio-out interface
		Kensington Security Slot
		Kinect connection port
		802.11 b/g/n dual-band WiFi
		Ethernet port
		Kinect 2.0
		Wireless controller
		Mono headset
		Category 2 4K-rated HDMI cable
		Power Brick and Power Cord

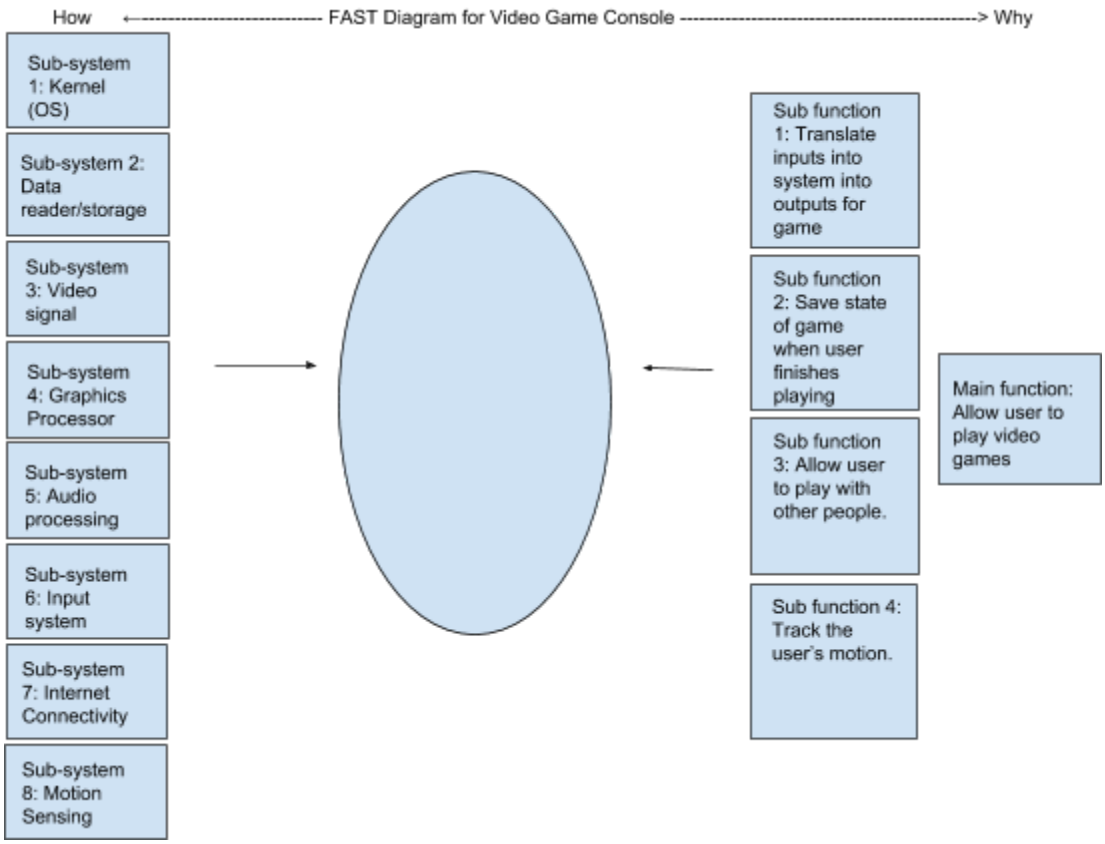
Step 3: Make a list of the main functions and the key sub-functions of the product.

Main functions	Sub-functions
Allow users to play video games.	- Allow users to play through games, taking inputs from the user, and showing what happens in the game based on those inputs. - Display game graphics on television - Play audio
Save state of game for each game the user plays	- Track place where user is in the game - Save whatever metrics related to the game user has acquired when they stop playing.
Allow user to play with other people	- Connect to the internet - Support multiplayer game modes - Save the user's progress to servers
Track the users motion	- Sense the users motion so that the user can "enter" input by moving.

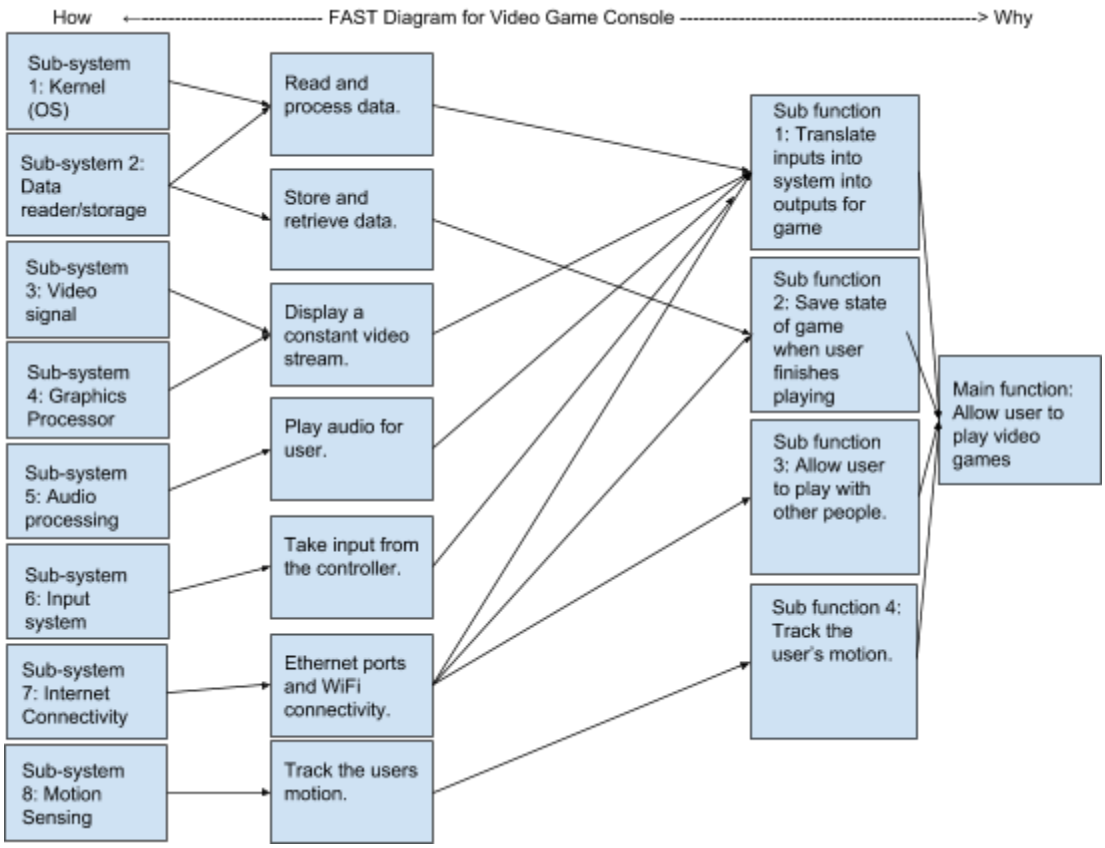
Step 4: Write down the main function for the system.

To allow users to play video games, often with other people through the internet, saving the state of each game the user has played so they can begin playing from the point they last stopped playing any particular game.

Step 5: Organize the "bones" of the FAST diagram.



Step 6: Create a FAST diagram for our product.



SP3: Dissect a virtual reality headset.

Step 1: Understand how the Oculus Rift works by researching online.

Step 2: Make a structured list of the important subsystems and components that are relevant.

System	Subsystems	Components
Oculus Rift	Headset	- Vision Lenses - HDMI Cable - USB Cable - DVI Cable - HDMI to DVI Adapter - 5-volt power supply - LCD Display Screen
	Control Box	- HDMI, DVI, mini-USB and DC power connection ports - Buttons for controlling contrast, brightness, and power - LED

	Sensor Unit	- Gyroscope - Accelerometer - Magnetometer - ARM X-3 Microcontroller

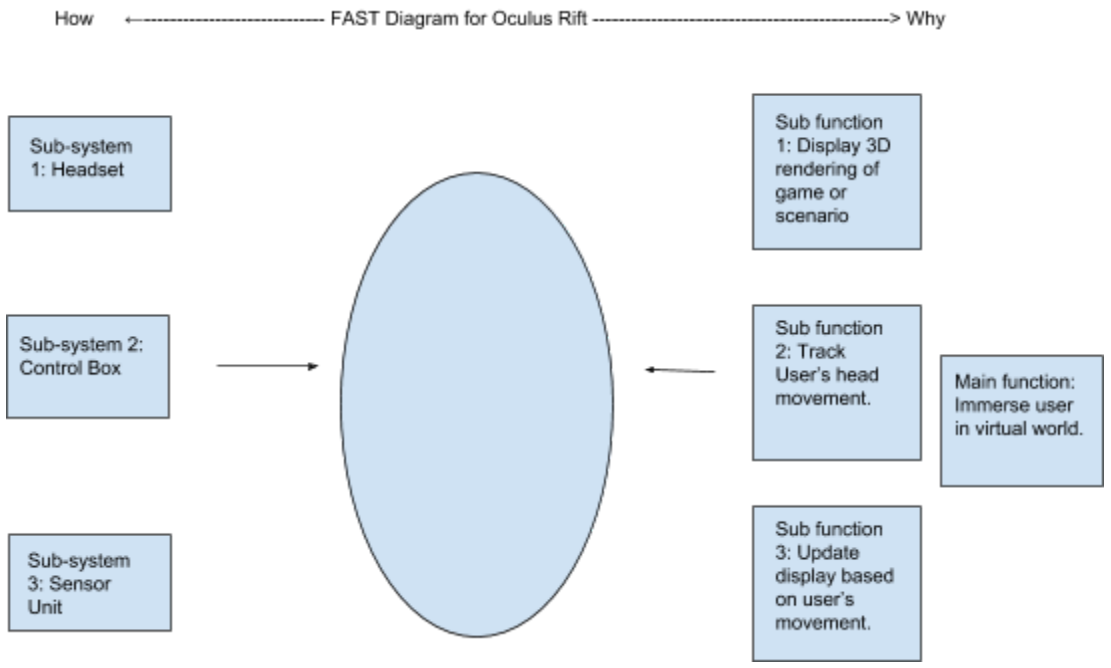
Step 3: Make a list of the main functions and the key sub-functions of the product.

Main functions	Sub-functions
Display a virtual world	Display a 3D stereoscopic rendering, high-resolution display of the game or scenario
	Track head movement of the user
	Update rendering based on user's movement

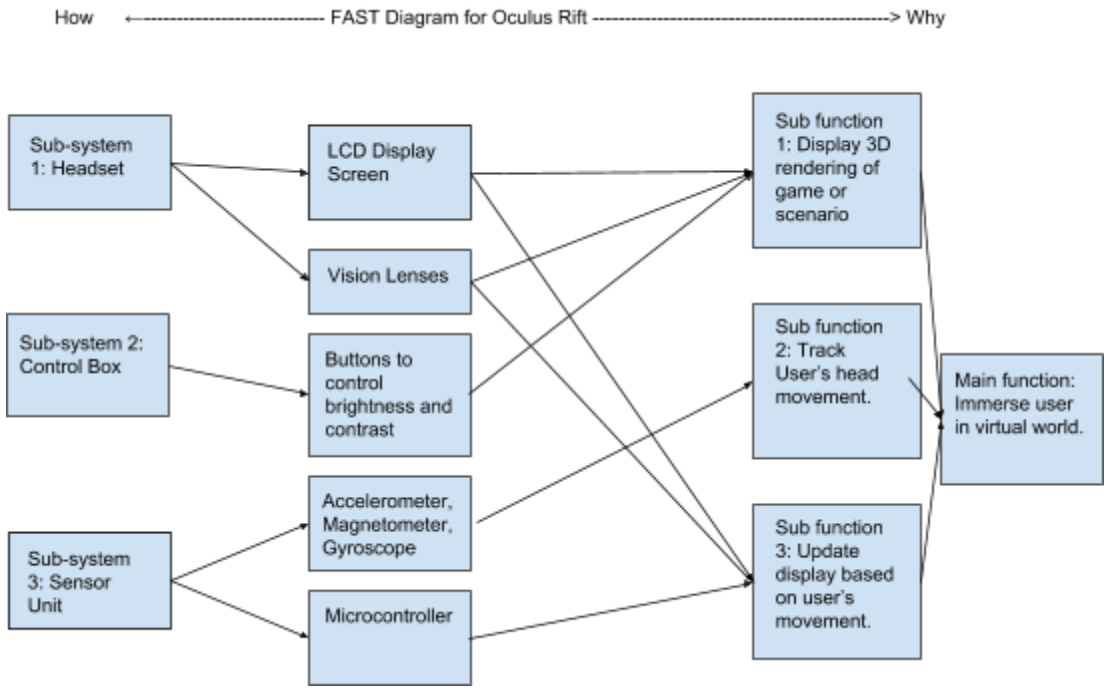
Step 4: Write down the main function for the system.

Display a virtual world to immerse the user into a game they are playing or another scenario they would like to imagine theirself in.

Step 5: Organize the "bones" of the FAST diagram.



Step 6: Create a FAST diagram for our product.



SP4: Dissect a video-game motion-tracking sensor.

Step 1: Understand how the Microsoft Kinect works by researching online.

Step 2: Make a structured list of the important subsystems and components that are relevant.

System	Subsystem	Components
Microsoft Kinect	Movement sensing hardware	- Color VGA video camera - Depth sensor - Multi-array microphone - Power supply
	Body and voice recognition software	- Machine learning algorithm - Microprocessor

Step 3: Make a list of the main functions and the key sub-functions of the product.

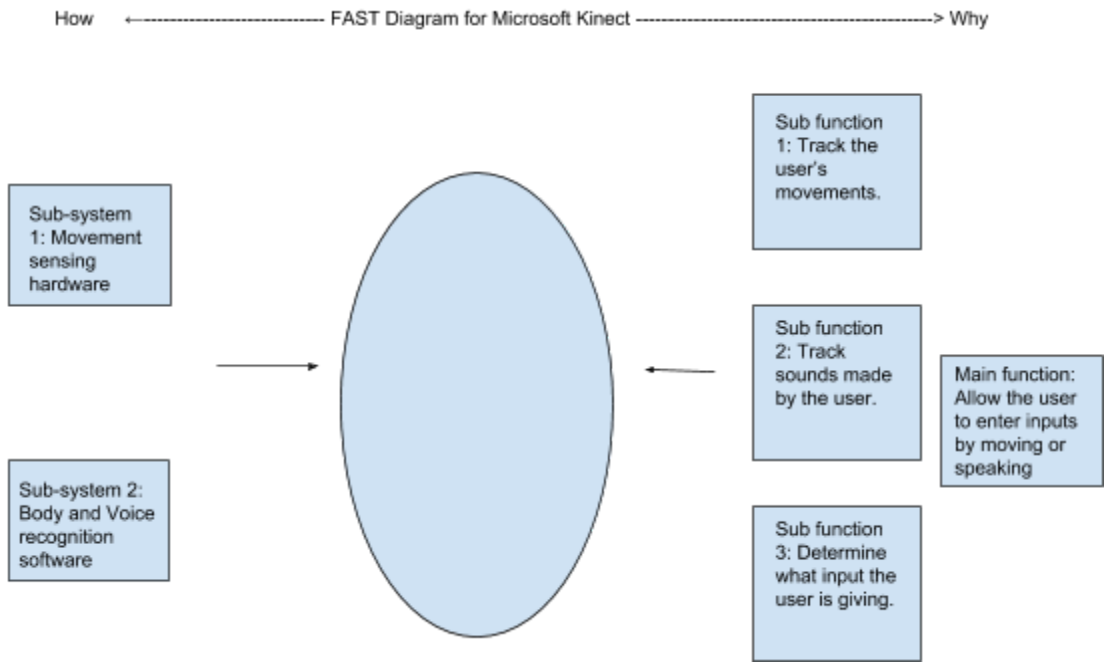
Main functions	Subfunctions
Track the user's movements and use them as input for a video game.	Track the users movements.
	Track sounds made by the user.
	Compare the movement made by the user with known movements and determine what

	input the user is giving.

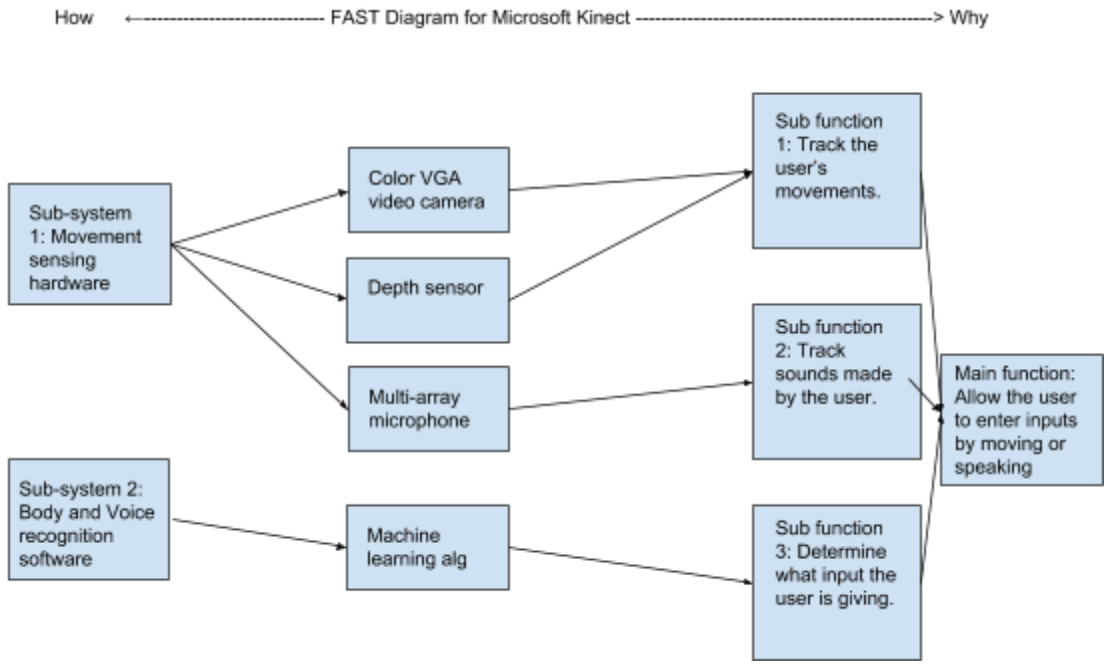
Step 4: Write down the main function for the system.

Allow the user to enter inputs for a video game by moving or speaking.

Step 5: Organize the “bones” of the FAST diagram.



Step 6: Create a FAST diagram for our product.



SP5: Create a feasible concept for a VR entertainment system based on the given sub-functions, and provide a concise explanation of how the product concept works.

Step 1: Establish customer needs and technical metrics/specifications for the new products using the HOQ.

No.	Customer Need	Importance
1	See graphics of video game	9
2	Hear audio corresponding to what's occurring in game	8
3	Can enter input to control what's happening in game by moving	9
4	Be able to start from last place they saved a game	9
5	Be able to play many different games	7
6	Console needs to read data from games entered	9
7	Provide immersive virtual experience	8

No.	Needs #	Metric	Importance	Units
1	1	Graphics Chips and Video Display	9	Binary
2	1	Memory dedicated to Graphics	8	Int
3	1	Number of colors	5	Int
4	2	Audio output	8	Type
5	3	User Control Interface	7	Type
6	3	Motion Tracking Sensor	8	Type
6	4	RAM memory size	8	Int
7	5,6	Has game reader	7	Binary
8	5,6	Type of game reader	5	Type
9	1,2,3	Microprocessor size	7	Bits
10	7	VR Headset	9	Binary

No.	Needs #	Metric	Units	Value

1	1	Graphics Chips and Video Display	Binary	Yes
2	1	Memory dedicated to Graphics	Int	1 MB
3	1	Number of colors	Int	4.2 million
4	2	Audio output	Type	32 bit, 48 channel ADPCM
5	3	User control Interface	Type	Controller with D-pad
6	4	RAM memory size	Int	2.5 MB
7	5,6	Has game reader	Binary	Yes
8	5,6	Type of game reader	Type	CD's
9	1,2,3	Microprocessor size	Bits	32 bit
10	7	VR Headset	Binary	Yes

Step 2: Identify the main function of the product (i.e. the product intent).

Provide the user with an immersive virtual reality gaming experience.

Step 3: Identify one or more related products and dissect them using FAST (will be done in SP2-SP4).

I dissected the Microsoft Xbox1, Oculus Rift, and Microsoft Kinect in SP2-SP4.

Step 4: Create an abstract representation of the new (intended) product, called the Function Structure.

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

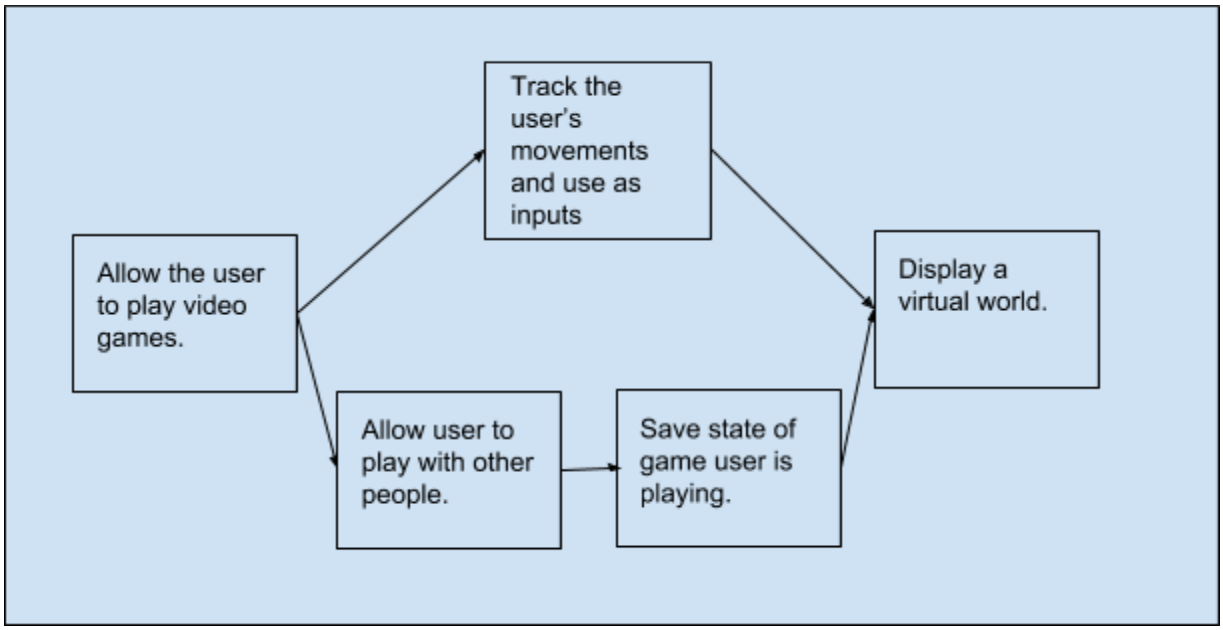
Main function	Inputs	Outputs
Provide the user with an immersive virtual reality gaming experience.	Movements the user makes to control the game Sounds the user makes to control the game Inputs from the controller	Picture displayed to LCD screens of VR headset Sound played by either VR headset or sound system

Step 2: Identify the sub-functions of the product.

1st Level Sub-functions	2nd Level Sub-functions

Display a virtual world	- Display a 3D stereoscopic rendering, high-resolution display of the game or scenario - Track head movement of the user - Update rendering based on user's movement
Track the user's movements and use them as input for a video game.	- Track the users movements. - Track sounds made by the user. - Compare the movement made by the user with known movements and determine what input the user is giving.
Allow users to play video games.	- Allow users to play through games, taking inputs from the user, and showing what happens in the game based on those inputs. - Display game graphics on television - Play audio
Save state of game for each game the user plays	- Track place where user is in the game - Save whatever metrics related to the game user has acquired when they stop playing.
Allow user to play with other people	- Connect to the internet - Support multiplayer game modes - Save the user's progress to servers
Support different video monitor display technologies	

Step 3: Draw the a transparent box model



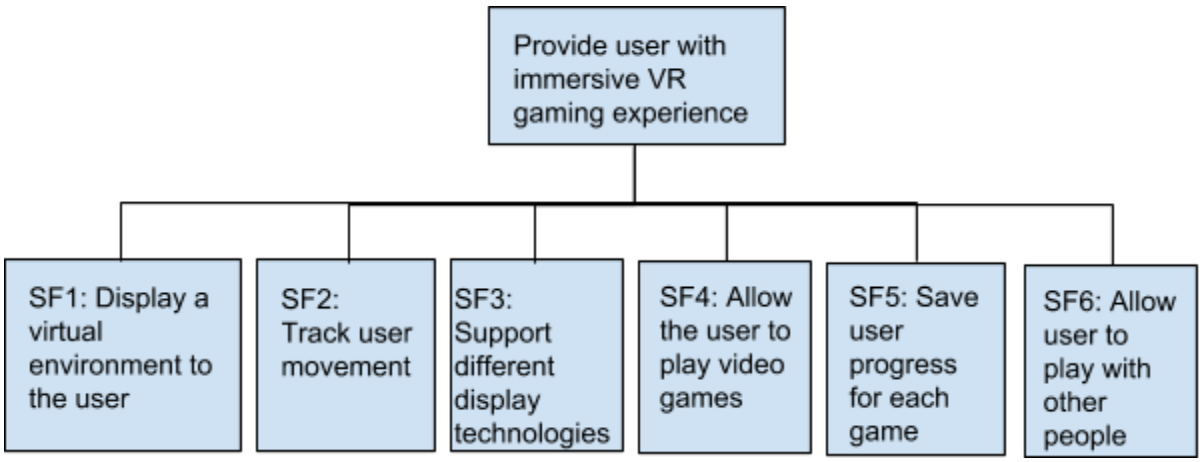
Step 4: Draw the system boundary.

Step 5: Identify the subsystems and components needed to perform the sub-functions

System	Subsystems	Components
VR entertainment system	Game Console	- Kernel (OS) - Data reader/storage - Video signal - Graphics processor - Audio processor - Input System - Internet Connectivity
	VR headset	- Vision Lenses - LCD Display Screen - Buttons for controlling contrast, brightness, and power

		- Gyroscope - Accelerometer - Magnetometer - Microprocessor
	Motion Sensor	- Color VGA video camera - Depth sensor - Multi-array microphone - Machine learning algorithm - Microprocessor

Step 6: Create the FS diagram.



Step 5: i) for each sub-function, generate alternative solution principles for realizing that sub-function.

ii) Create a Morphological Matrix.

	SP1	SP2	SP3	SP4
SF1: Display a virtual environment	VR headset	VR helmet	VR glasses	VR goggles
SF2: Track user movements	Use Kinect we already develop	Create motion sensing camera compatible with other consoles	Bodysuit with motion sensors	Motion tracking controller (i.e. Wii)
SF3: Support different video monitor display technologies	Full HD resolution display technology	2k resolution display technology	4k resolution display technology	HD resolution display technology

SF4: Allow user to play video games	Use the Xbox 1 console we develop	Develop a new video game console	Integrate other consoles into VR system	Exclusively use the PlayStation.
SF5: Save user progress for each game	Save to local memory	Save to centralized servers	Hybrid of SP1 and SP2	Save to USB or other removable memory
SF6: Allow user to play with other people.	Have local (i.e. only on the console) multiplayer game modes	Only use Xbox live	Hybrid of SP1 and SP2	Develop a different online gaming platform

Step 6: Generate 4-6 alternative concepts for the new product design.

Concept 1: We use VR glasses, track the user's movements using the Microsoft Kinect, use Full HD as the resolution display technology, use the Xbox 1 as the system's game console, save the user's progress to local memory, and support multiplayer game modes locally on the console. This has the benefit of using existing Microsoft technology for everything but the VR glasses and thus would be relatively cheap to get to market, but would leave the user isolated from the rest of the gaming community.

Concept 2: We use a VR headset, track the user's movements using the Microsoft Kinect, use Full HD as the resolution display technology, use the Xbox 1 as the system's game console, save the user's progress to centralized servers, and support multiplayer game modes only on Xbox live. Again we have the benefit of using existing Microsoft technology except for the VR headset, but this time we support online gaming. However, since no data can be saved locally, all gaming must be done online forcing all users to purchase an Xbox live subscription.

Concept 3: We use a VR headset, track the user's movements using the Microsoft Kinect, use 2K resolution display technology, use the Xbox 1 as the system's game console, save the user's progress both locally and to centralized servers, and support multiplayer game modes locally on the console and on Xbox live. We are able to use existing microsoft technology except for the VR headset, and the user is able to play online or offline.

Concept 4: We use a VR helmet, track the user's movements using a motion sensor compatible with other consoles (and the Xbox 1), use 4K resolution display technology, allow other consoles to be integrated into the VR system, save the user's progress both locally and to centralized servers, and support multiplayer game modes locally on the console and on Xbox live. This would allow users to use whatever console they prefer, but would have the issue of being expensive to make and difficult to perfect.

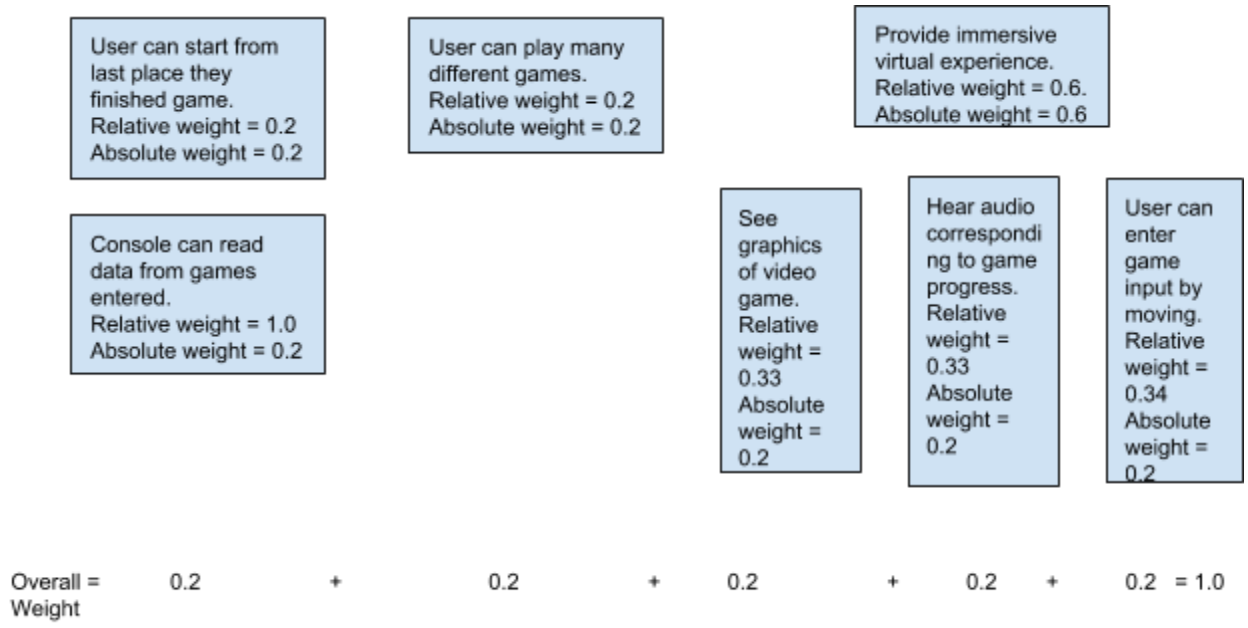
Step 7: Identify a set of selection criteria to assess/compare these alternatives, and use these selection criteria to construct a Utility Function.

The selection criteria are the customer needs identified in step 1 of this process.

No.	Customer Need	Importance

1	See graphics of video game	9
2	Hear audio corresponding to what's occurring in game	8
3	Can enter input to control what's happening in game by moving	9
4	Be able to start from last place they saved a game	9
5	Be able to play many different games	7
6	Console needs to read data from games entered	9
7	Provide immersive virtual experience	8

We now organize these selection criteria into a hierarchy based on their importance.



We now have the utility function needed to select the best design concept.

Step 8: Use the utility function to compare the alternatives generated in Step 6, and select one concept for further development.

I am using a scale from 1-5.

Selection Criteria	Absolute Weight	Concept 1 Rating | Utility	Concept 2 Rating | Utility	Concept 3 Rating | Utility	Concept 4 Rating | Utility
Can read data from games.	0.2	5 | 1	5 | 1	5 | 1	4 | 0.8
User can	0.2	4 |	4 |	4 |	5 |

play many different games		0.8	0.8	0.8	1
User can see video game graphics	0.2	3 | 0.6	5 | 1	5 | 1	3 | 0.6
User can hear audio corresponding to game	0.2	2 | 0.4	4 | 0.8	4 | 0.8	5 | 1
User can enter game input by moving.	0.2	4 | .8	5 | 1	5 | 1	3 | .6
Overall Cumulative Utility	1	3.6	4.6	4.6	4

Concepts 2 and 3 have the highest cumulative utility, and I will proceed the development of concept 3 as I believe the 2K resolution display technology has more value in the market than the Full HD resolution display technology.

SP6: Develop a product platform and three product lines for different market segments.

Step 1: Determine the core technology elements, unique to the product, and the other supporting technology elements.

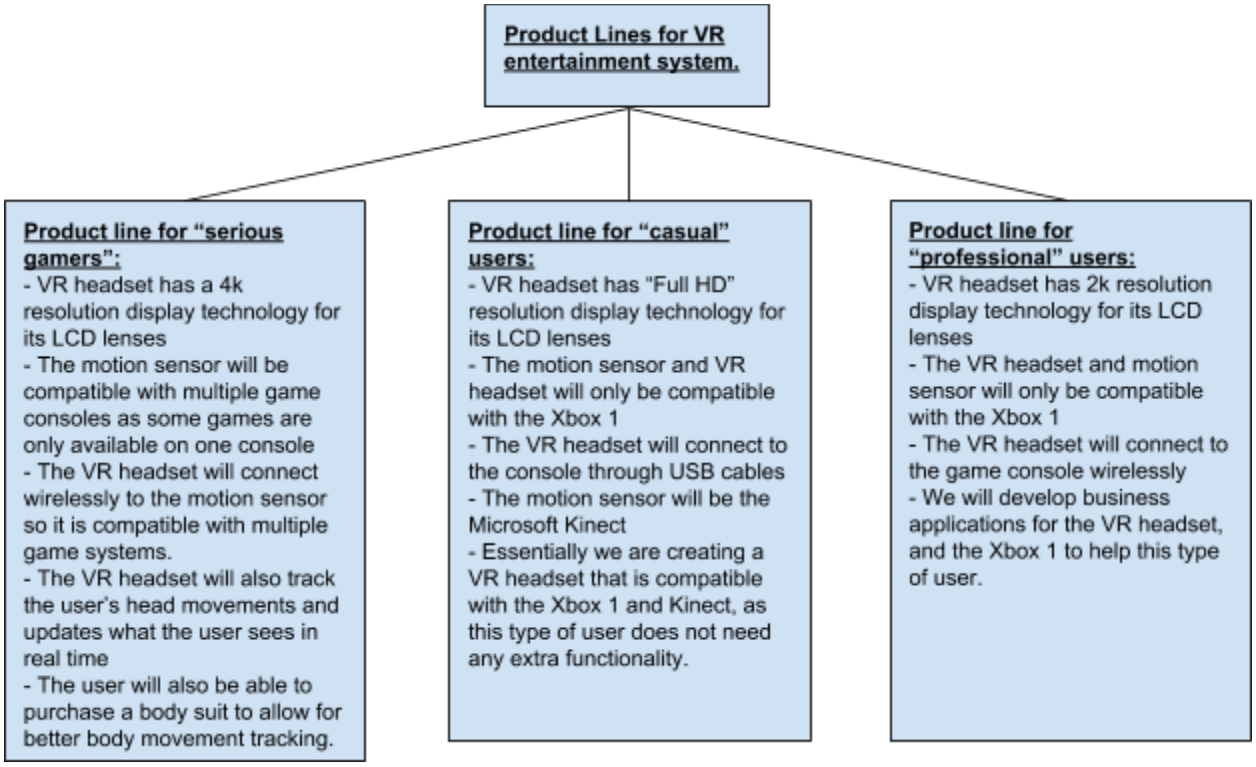
Core technology elements	Supporting technology elements
VR headset	- Vision Lenses - LCD Display Screen - Buttons for controlling contrast, brightness, and power - Gyroscope - Accelerometer - Magnetometer - Microprocessor - Connection to video game console output
Video Game Console	- Kernel (OS) - Data reader/storage - Video signal

	- Graphics processor - Audio processor - WiFi/Ethernet ports
Motion Sensor	- Color VGA video camera - Depth sensor - Multi-array microphone - Machine learning algorithm - Microprocessor

Step 2: Determine the market segments we need to create a product line for.

Market segment	Needs
“serious gamer”	Users who are almost exclusively interested in high-resolution graphics and a realistic VR experience for playing video games
“casual”	Users who are interested in using VR to have new experiences, e.g. travel, meditation, and education
“professional”	Users who are interested in using VR for business applications such as designing and prototyping new products.

Step 3: Determine the product lines for these market segments.



SP7: Develop an FMEA of the product line for "serious gamers" and identify the three most critical failure modes.

Step 1: Create a FAST diagram for the VR entertainment system to identify the key subsystems and components of the product and the key sub-functions of these subsystems.

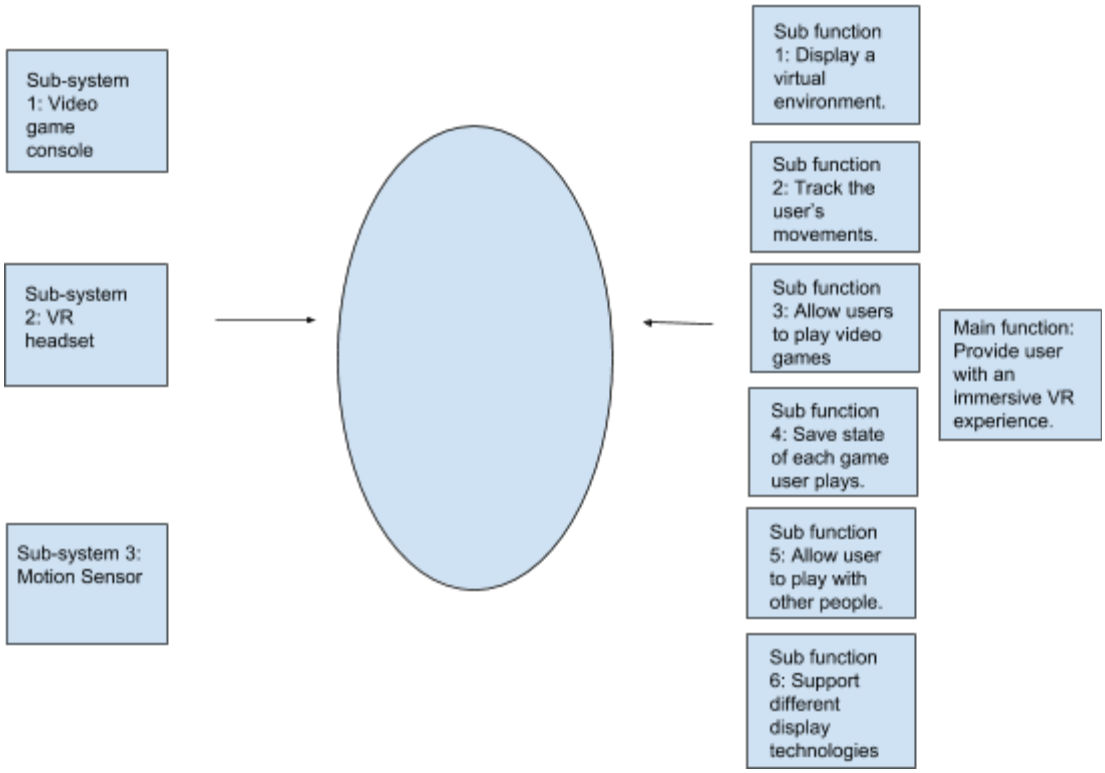
System	Subsystems	Components
VR entertainment system	Game Console	- Kernel (OS) - Data reader/storage - Video signal - Graphics processor - Audio processor - Input System - Internet Connectivity
	VR headset	- Vision Lenses - LCD Display Screen - Buttons for controlling contrast, brightness, and power - Gyroscope - Accelerometer - Magnetometer - Microprocessor

	Motion Sensor	- Color VGA video camera - Depth sensor - Multi-array microphone - Machine learning algorithm - Microprocessor

1st Level Sub-functions	2nd Level Sub-functions
Display a virtual world	- Display a 3D stereoscopic rendering, high-resolution display of the game or scenario - Track head movement of the user - Update rendering based on user's movement
Track the user's movements and use them as input for a video game.	- Track the users movements. - Track sounds made by the user. - Compare the movement made by the user with known movements and determine what input the user is giving.
Allow users to play video games.	- Allow users to play through games, taking inputs from the user, and showing what happens in the game based on those inputs. - Display game graphics on television - Play audio
Save state of game for each game the user plays	- Track place where user is in the game - Save whatever metrics related to the game user has acquired when they stop playing.
Allow user to play with other people	- Connect to the internet - Support multiplayer game modes - Save the user's progress to servers
Support different video monitor display technologies	

The main function of the system is to provide the user with an immersive virtual reality gaming experience.

How ←---------- FAST Diagram for VR entertainment system ----------> Why



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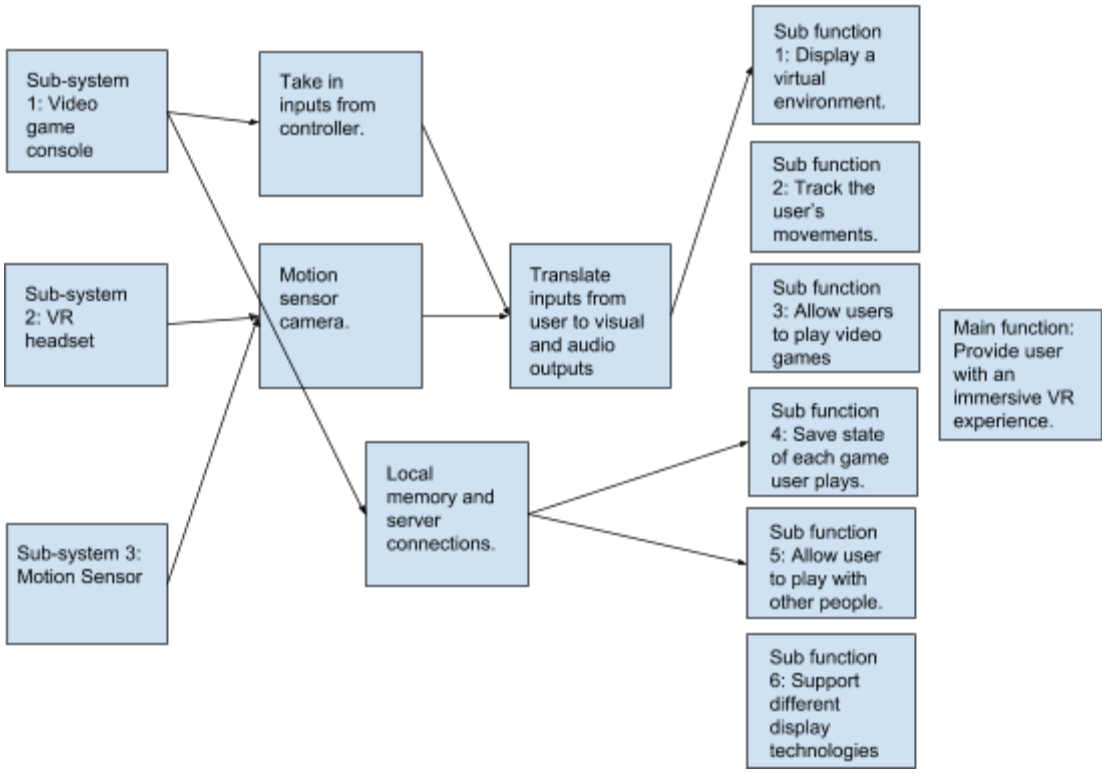


Step 2: For each subsystem identify potential failure modes, and characterize these failure modes using a Risk Priority Number.

Function	**Potential Failure Mode**	**Potential Effect of Failure**	**Severity**	**Potential Cause of Failure**	**Occurrence**	**How will it be detected ?**	**Detection**	**RPN**
Display a virtual world	VR Headset fails to display graphics or play audio.	Give the customer a refund	7	Transmission to headset not working	2	Beta-testing	3	42
Track the user's movements and use them as input for a video game.	User's movement not understood properly	System does not allow user to control system properly	5	Camera does not map room/user properly	2	Beta-testing	5	50
Allow users to play video games.	Console doesn't play game properly	User can't play game they want	2	Software bug/could be hardware issue	1	Beta-testing	4	8
Save state of game for each game the user plays	Local memory doesn't work	User will have to restart from earlier part of game	1	Memory failure	3	Alpha-testing	1	9
Allow user to play with other	Internet connection fails	Customers don't want to purchase	5	WiFi/ethernet ports are broken	2	Customer feedback	1	10

people		system, as they are isolated from other gamers						
Support different video monitor display technologies	User doesn't have compatible monitor	System can't show graphics	6	Resolution display technology of system is incompatible with user's system	1	Customer Feedback	2	12

Step 4: Check your work.

I am confident that all my work is correct.

Step 5: Learn and generalize.

We can the use the product conceptual design process to create multiple different design concepts for a new product, and then pick the concept with the highest utility and least chance of failure. I will go forward with design concept 3 for the VR entertainment system because it allows us to maintain a high level of vertical integration, and thus carries less technological risk than the other potential concepts. Since this concept should be relatively easy and cheap to product, I would recommend moving forward with its development.

3. Financial Modeling For The Virtual Reality Entertainment System.

The software gian has asked you to model the impact of the unit sales price on the Net Present Value (NPV) of the project. Perform a four-year quarterly NPV analysis (assume a discount factor of 10% per year) in order to determine the following:

a) The minimum value, of the unit sales price for the product that will result in a positive NPV by the end of year 4.
b) What is the trade-off law between NPV and unit sales price?
c) What price would you recommend that the software giant charge a wholesale distributor (e.g. Costco) for 1 unit of the VR entertainment system? Explain your answer.
d) What is the expected NPV based on your recommended sales price from part (c).

Step 1: Define the problem.

SP1: What is the minimum value of the sales price of the product that will result in a positive NPV by the end of year 4.

SP2: What is the trade off law between NPV and unit sales price.

SP3: What price should we charge a wholesale distributor for 1 unit of the VR entertainment system.

SP4: What is the expected NPV based on my recommended sales price.

Step 2: Plan to solve the problem.

Assumptions: The values for the costs of the product and the schedule is correct. A 10% increase in unit sales price will cause a 10% decrease in the number of units sold and thus a 10% decrease in the sales and production volume of the product.

Available information: The PD&D book, class notes, information on the internet about how the products that need to be dissected work, and work done on the midterm that relates to this problem.

SP1: Find the minimum unit price that will in a positive NPV.

Step 1: Create a base-case (nominal) model in excel with the given information.

Step 2: Adjust the unit sales price until the NPV is 0.

SP2: What is the trade off law between NPV and unit sales price.

Step 1: Perform a sensitivity analysis changing the unit sales price.

Step 2:

SP3: Price per unit for sales to wholesale distributor.

SP4: Expected NPV based on my unit sales price.

Step 3: Execute the plan.

SP1: SP1: Find the minimum unit price that will in a positive NPV.

Step 1: Create a base-case (nominal) model in excel with the given information. First I set the unit sales price equal to the unit production cost, $125. The NPV is -$43,782, and the spreadsheet looks as follows.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	BaseCase																
2		Year 1				Year 2				Year 3				Year 4			
3	period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
4	($ values in thousands)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16
5																	
6	Development Cost	-10,000	-10,000	-10,000	-10,000												
7	Ramp-up Cost				-250	-250											
8	Marketing & Support Cost					-500	-500	-500	-500	-500	-500	-500	-500	-500	-500	-500	-500
9	Production Cost						-15,625	-15,625	-15,625	-15,625	-15,625	-15,625	-15,625	-15,625	-15,625	-15,625	-15,625
10	Production Volume						125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000
11	Unit Production Cost						0	0	0	0	0	0	0	0	0	0	0
12	Sales Revenue						15,625	15,625	15,625	15,625	15,625	15,625	15,625	15,625	15,625	15,625	15,625
13	Sales Volume						125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000
14	Unit Price						0	0	0	0	0	0	0	0	0	0	0
15																	
16	Period Cash Flow	-10,000	-10,000	-10,000	-10,250	-750	-500	-500	-500	-500	-500	-500	-500	-500	-500	-500	-500
17	PV Year 1, r = 10%	-10,000	-9,756	-9,518	-9,518	-679	-442	-431	-421	-410	-400	-391	-381	-372	-363	-354	-345
18																	
19	Project NPV, $	-43,782															
20																	
21																	

Step 2: Adjust the unit sales price until the NPV is 0.

Testing different numbers I found that the NPV of the project is 0 when the unit sales price is $165.635.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	BaseCase																	
2		Year 1				Year 2				Year 3				Year 4				
3	period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
4	($ values in thousands)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	
5																		
6	Development Cost	-10,000	-10,000	-10,000	-10,000													
7	Ramp-up Cost				-250	-250												
8	Marketing & Support Cost					-500	-500	-500	-500	-500	-500	-500	-500	-500	-500	-500	-500	
9	Production Cost						-15,625	-15,625	-15,625	-15,625	-15,625	-15,625	-15,625	-15,625	-15,625	-15,625	-15,625	
10	Production Volume						125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	
11	Unit Production Cost						0	0	0	0	0	0	0	0	0	0	0	
12	Sales Revenue						20,704	20,704	20,704	20,704	20,704	20,704	20,704	20,704	20,704	20,704	20,704	
13	Sales Volume						125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	
14	Unit Price						0	0	0	0	0	0	0	0	0	0	0	
15																		
16	Period Cash Flow	-10,000	-10,000	-10,000	-10,250	-750	4,579	4,579	4,579	4,579	4,579	4,579	4,579	4,579	4,579	4,579	4,579	
17	PV Year 1, r = 10%	-10,000	-9,756	-9,518	-9,518	-679	4,048	3,949	3,852	3,759	3,667	3,577	3,490	3,405	3,322	3,241	3,162	
18																		
19	Project NPV, $	0																
20																		
21																		

SP2: What is the trade off law between NPV and unit sales price.

Step 1: Perform a sensitivity analysis changing the unit sales price.

First I will calculate the NPV if I drop the unit sales price by 20% to 132.508.

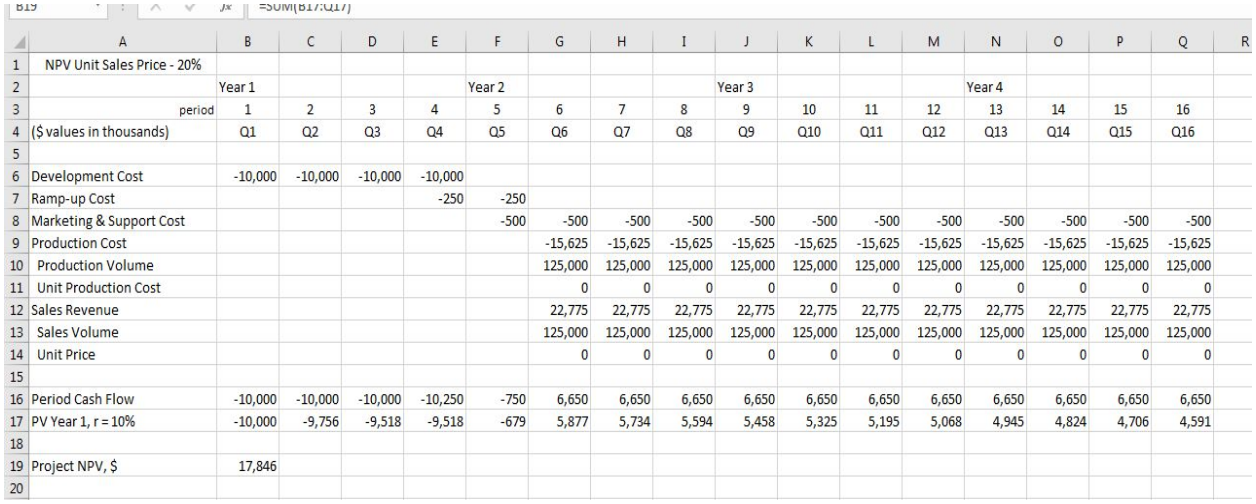
F12

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	NPV Unit Sales Price - 20%																	
2		Year 1				Year 2				Year 3				Year 4				
3	period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
4	($ values in thousands)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	
5																		
6	Development Cost	-10,000	-10,000	-10,000	-10,000													
7	Ramp-up Cost				-250	-250												
8	Marketing & Support Cost					-500	-500	-500	-500	-500	-500	-500	-500	-500	-500	-500	-500	
9	Production Cost						-15,625	-15,625	-15,625	-15,625	-15,625	-15,625	-15,625	-15,625	-15,625	-15,625	-15,625	
10	Production Volume						125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	
11	Unit Production Cost						0	0	0	0	0	0	0	0	0	0	0	
12	Sales Revenue						16,564	16,564	16,564	16,564	16,564	16,564	16,564	16,564	16,564	16,564	16,564	
13	Sales Volume						125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	
14	Unit Price						0	0	0	0	0	0	0	0	0	0	0	
15																		
16	Period Cash Flow	-10,000	-10,000	-10,000	-10,250	-750	439	439	439	439	439	439	439	439	439	439	439	
17	PV Year 1, r = 10%	-10,000	-9,756	-9,518	-9,518	-679	388	378	369	360	351	343	334	326	318	310	303	
18																		
19	Project NPV, $	-35,692																
20																		

The new NPV is -$35.692 million. Next I will calculate the NPV if I drop the unit sales price by 10% to 149.0715.

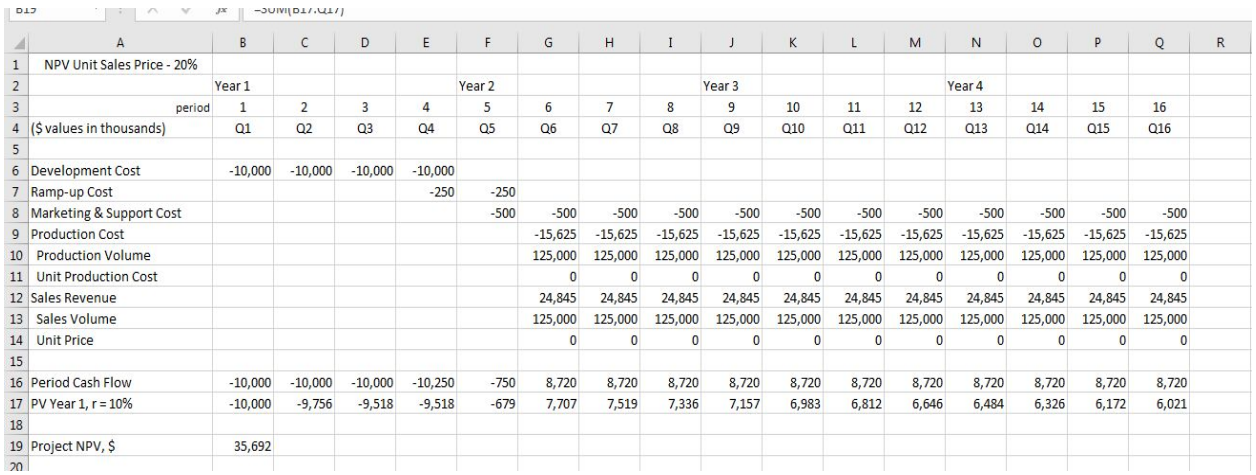
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	NPV Unit Sales Price - 20%																	
2		Year 1				Year 2				Year 3				Year 4				
3	period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
4	($ values in thousands)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	
5																		
6	Development Cost	-10,000	-10,000	-10,000	-10,000													
7	Ramp-up Cost				-250	-250												
8	Marketing & Support Cost					-500	-500	-500	-500	-500	-500	-500	-500	-500	-500	-500	-500	
9	Production Cost						-15,625	-15,625	-15,625	-15,625	-15,625	-15,625	-15,625	-15,625	-15,625	-15,625	-15,625	
10	Production Volume						125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	
11	Unit Production Cost						0	0	0	0	0	0	0	0	0	0	0	
12	Sales Revenue						18,634	18,634	18,634	18,634	18,634	18,634	18,634	18,634	18,634	18,634	18,634	
13	Sales Volume						125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	
14	Unit Price						0	0	0	0	0	0	0	0	0	0	0	
15																		
16	Period Cash Flow	-10,000	-10,000	-10,000	-10,250	-750	2,509	2,509	2,509	2,509	2,509	2,509	2,509	2,509	2,509	2,509	2,509	
17	PV Year 1, r = 10%	-10,000	-9,756	-9,518	-9,518	-679	2,218	2,163	2,111	2,059	2,009	1,960	1,912	1,866	1,820	1,776	1,732	
18																		
19	Project NPV, $	-17,846																
20																		
21																		

The new NPV is -$17.846 million. Next I will calculate the NPV if I increase the unit sales price by 10% to 182.1985.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	NPV Unit Sales Price - 20%																	
2		Year 1				Year 2				Year 3				Year 4				
3	period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
4	($ values in thousands)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	
5																		
6	Development Cost	-10,000	-10,000	-10,000	-10,000													
7	Ramp-up Cost				-250	-250												
8	Marketing & Support Cost					-500	-500	-500	-500	-500	-500	-500	-500	-500	-500	-500	-500	
9	Production Cost						-15,625	-15,625	-15,625	-15,625	-15,625	-15,625	-15,625	-15,625	-15,625	-15,625	-15,625	
10	Production Volume						125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	
11	Unit Production Cost						0	0	0	0	0	0	0	0	0	0	0	
12	Sales Revenue						22,775	22,775	22,775	22,775	22,775	22,775	22,775	22,775	22,775	22,775	22,775	
13	Sales Volume						125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	
14	Unit Price						0	0	0	0	0	0	0	0	0	0	0	
15																		
16	Period Cash Flow	-10,000	-10,000	-10,000	-10,250	-750	6,650	6,650	6,650	6,650	6,650	6,650	6,650	6,650	6,650	6,650	6,650	
17	PV Year 1, r = 10%	-10,000	-9,756	-9,518	-9,518	-679	5,877	5,734	5,594	5,458	5,325	5,195	5,068	4,945	4,824	4,706	4,591	
18																		
19	Project NPV, $	17,846																
20																		

The new NPV is $17.846 million. Next I will calculate the NPV if I increase the unit sales price by 20% to 198.762.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	NPV Unit Sales Price - 20%																	
2		Year 1				Year 2				Year 3				Year 4				
3	period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
4	($ values in thousands)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	
5																		
6	Development Cost	-10,000	-10,000	-10,000	-10,000													
7	Ramp-up Cost				-250	-250												
8	Marketing & Support Cost					-500	-500	-500	-500	-500	-500	-500	-500	-500	-500	-500	-500	
9	Production Cost						-15,625	-15,625	-15,625	-15,625	-15,625	-15,625	-15,625	-15,625	-15,625	-15,625	-15,625	
10	Production Volume						125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	
11	Unit Production Cost						0	0	0	0	0	0	0	0	0	0	0	
12	Sales Revenue						24,845	24,845	24,845	24,845	24,845	24,845	24,845	24,845	24,845	24,845	24,845	
13	Sales Volume						125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000	
14	Unit Price						0	0	0	0	0	0	0	0	0	0	0	
15																		
16	Period Cash Flow	-10,000	-10,000	-10,000	-10,250	-750	8,720	8,720	8,720	8,720	8,720	8,720	8,720	8,720	8,720	8,720	8,720	
17	PV Year 1, r = 10%	-10,000	-9,756	-9,518	-9,518	-679	7,707	7,519	7,336	7,157	6,983	6,812	6,646	6,484	6,326	6,172	6,021	
18																		
19	Project NPV, $	35,692																
20																		

The new NPV is $35.692 million. We can see that a 10% change in unit sales price leads to a $17.846 million change in the project's NPV.

Factor	Trade-Off Rule	Comments
Unit sales price	$17.846 million change to NPV per $16.56 change to unit sales price.	Sales make up all of the projects revenue so unit sale price has a big effect of profitability of project.

SP3: Price per unit for sales to wholesale distributor.

We have to choose a price above $165.635 in order to have positive NPV for the project, but choosing to high a price will decrease the sales volume. I am assuming a 10% increase in unit sales price will decrease sales and production volume by 10% as less people will want to purchase a more expensive product. The highest project NPV occurs when the unit

sales price is raised by 45% to $240.17 and the production and sales volume decreases by 45% to 275,000 units. The NPV with these values is $26.430 million. ANy deviation from this unit sales price causes the NPV of the project to decrease.

SP4: Expected NPV based on my unit sales price.

Unit Sales Price	Project NPV
$240.17	$26.430 million

Step 4: Check your work.

I am confident that all my work is correct.

Step 5: Learn and Generalize.

If I am wrong and a 10% increase in unit sales price will cause more or less than a 10% decrease in sales volume it will affect the amount we should charge to get the highest sales value for the product. This project should be valuable and we should move forward into developing it. In general, we can use financial modeling to understand whether a project is likely to profitable and how changes to our expected costs and revenues will change the overall NPV.

4. Information Technology For Product Design and Development.

The software giant would like you to develop an Information Technology (IT) system to support the design and development of the proposed Virtual Reality (VR) entertainment system.

a) Develop your own Product Design and Development framework, based on the appropriate modification of the MDC framework handed out in class.
b) Design an IT system to automate and integrate the steps and stages in your framework. Your design should make use of the appropriate tools from this course, as well as tools from other courses such as software engineering, computer architecture, networking, and databases.

Step 1: Define the real problem.

SP1: Develop a Product Design and Development framework suited towards supporting the design of a VR entertainment system.

SP2: Design an IT system to automate and integrate the steps and stages in your framework.

Step 2: Plan how to solve the problem

SP1: Develop the framework.

Step 1: What is the framework provided in class.

Step 2: What steps should be changed for the development of a VR entertainment system.

Step 3: Write down the new framework.

SP2: Design an IT system to automate the framework.

-- how could a computer perform these above steps

Step 3: Execute the plan.

SP1: Develop the framework.

Step 1: What is the framework provided in class.

The MDC framework provided in class provides a framework for developing a product. The steps are as follows:

1. (Quality Function Deployment). Develop a comprehensive House of Quality (HOQ) to correlate customer needs to technical metrics and specifications.
2. (Reverse Engineering). Dissect existing products which are similar to the proposed new product using the Function Analysis Systems Technique (FAST).
3. (Conceptual Design). Create a function structure (FS) for your product, and use this FS to generate a morphological matrix (MM). Use the MM to generate several design concepts. Select one (or more) concepts using a utility function, which is based on an appropriate set of weighted selection criteria.
4. (Prototyping Strategy). Develop an appropriate prototyping strategy (physical vs. analytical; focused vs. comprehensive). Build and test proof-of concept and other appropriate prototypes based on the prototyping strategy.
5. (Product Architecture/Product Strategy). Establish the technology platform and product platform. Define the appropriate product lines to serve the target market segments (also see Steps 4, 6, 17).
6. (Detailed design). Develop the detailed embodiment design of the product
7. (FMEA).Perform a failure modes and effects analysis (FMEA) of the detailed design.
8. (DFX). Perform DFX: Design for manufacturability(X=M) and quality (X=Q)

Step 2: What steps should be changed for the development of a VR entertainment system.

In step 3 (Conceptual Design) we should also create a FAST Diagram of the product after selecting the concept with the highest cumulative utility.

Step 5 (Product Architecture/Product Strategy) should be performed before Step 4 (Prototyping Strategy), as it will be helpful to understand what the core and supporting technologies of the product are before developing a prototype with them.

Step 3: Write down the new framework.

1. (Quality Function Deployment). Develop a comprehensive House of Quality (HOQ) to correlate customer needs to technical metrics and specifications.
2. (Reverse Engineering). Dissect existing products which are similar to the proposed new product using the Function Analysis Systems Technique (FAST).
3. (Conceptual Design). Create a function structure (FS) for your product, and use this FS to generate a morphological matrix (MM). Use the MM to generate several design concepts. Select one (or more) concepts using a utility function, which is based on an appropriate set of weighted selection criteria. Then develop a FAST diagram for that concept.

4. (Product Architecture/Product Strategy). Establish the technology platform and product platform. Define the appropriate product lines to serve the target market segments (also see Steps 4, 6, 17).
5. (Prototyping Strategy). Develop an appropriate prototyping strategy (physical vs. analytical; focused vs. comprehensive). Build and test proof-of concept and other appropriate prototypes based on the prototyping strategy.
6. (Detailed design). Develop the detailed embodiment design of the product
7. (FMEA).Perform a failure modes and effects analysis (FMEA) of the detailed design.
8. (DFX). Perform DFX: Design for manufacturability(X=M) and quality (X=Q)

SP2: Design an IT system to automate the framework.

A web crawler would be used to perform steps 1 and 2, i.e. understanding what functions the product needs to perform and the technical metrics needed to make the product competitive in the market, and dissecting similar products to the VR entertainment system. We would write a program to determine the functions the product would perform, and use the web crawler to determine what subfunctions are needed to perform the the above functions. The web crawler would then research the energy flows throughout the product and the program would use them to create the FS diagram. We would create a different program to identify the core and supporting technologies and determine how to create different product lines. We again would develop a program that can create a prototype of the product and a more detailed design of the product. One last program would perform a FMEA and DFX for the product and determine whether we should move forward with the development of the product.

Step 4: Check your work.

I am confident that all my work is correct.

Step 5: Learn and generalize.

We can adjust the product design and development framework to help us develop any product. As technology has improved, we can automate large parts of these frameworks allowing any project to be more valuable by keeping costs down.

5. Conclusion

What are the key lessons that you learned in this course? Provide at least one example for each key lesson.

Step 1: Define the real problem.

SP1: What lessons did I learn during this course.

SP2: Give an example for each lesson.

Step 2: Plan how to solve the problem.

Assumptions: I was a student in this course and I am doing a post-course look at what I learned.

SP1: Lessons learned.

-- for each part of the MDC framework, what did I learn from each step.

SP2: Examples.

-- for each lesson learned, what did I do to drive the lesson home.

Step 3: Execute the plan.

SP1: Lessons learned.

-- I learned how to decide what a firm's high level strategy should be, and how to match the firm's strategies to these goals.

-- I learned how to translate customer needs into technical metrics to allow a firm to create a product that meets these needs.

-- I learned how to dissect existing products to understand how they work functionally and what systems are needed to perform those functions.

-- I learned how to perform a FMEA analysis to understand the potential failure points of any product.

-- I learned how to perform a financial analysis of a project.

SP2: Examples.

Lesson	Example(s)
How to decide what a firm's high level strategy should be, and how to match the firm's strategies to these goals.	We had to determine a product/market and technology strategy for the team project to match our business goals.
How to translate customer needs into technical metrics to allow a firm to create a product that meets these needs.	In the team project we had to create a HOQ to match the customer needs for our product to technical metrics we could implement.
How to dissect existing products to understand how they work functionally and what systems are needed to perform those functions.	We dissected three product in problem 2 of this final.
How to perform a FMEA analysis to understand the potential failure points of any product.	I performed a FMEA analysis of the VR entertainment system designed in this final.
How to perform a financial analysis of a project.	Problem 3 of this final.

Step 4: Check your work.

I am confident that all my work is correct.

Step 5: Learn and generalize.

I learned the process of designing, developing, managing, and commercializing products. This process can be used to develop any new product.