



The Role of the Product/Engineering Designer

Week 1: First Lecture

Design is a responsibility, not just a technical task

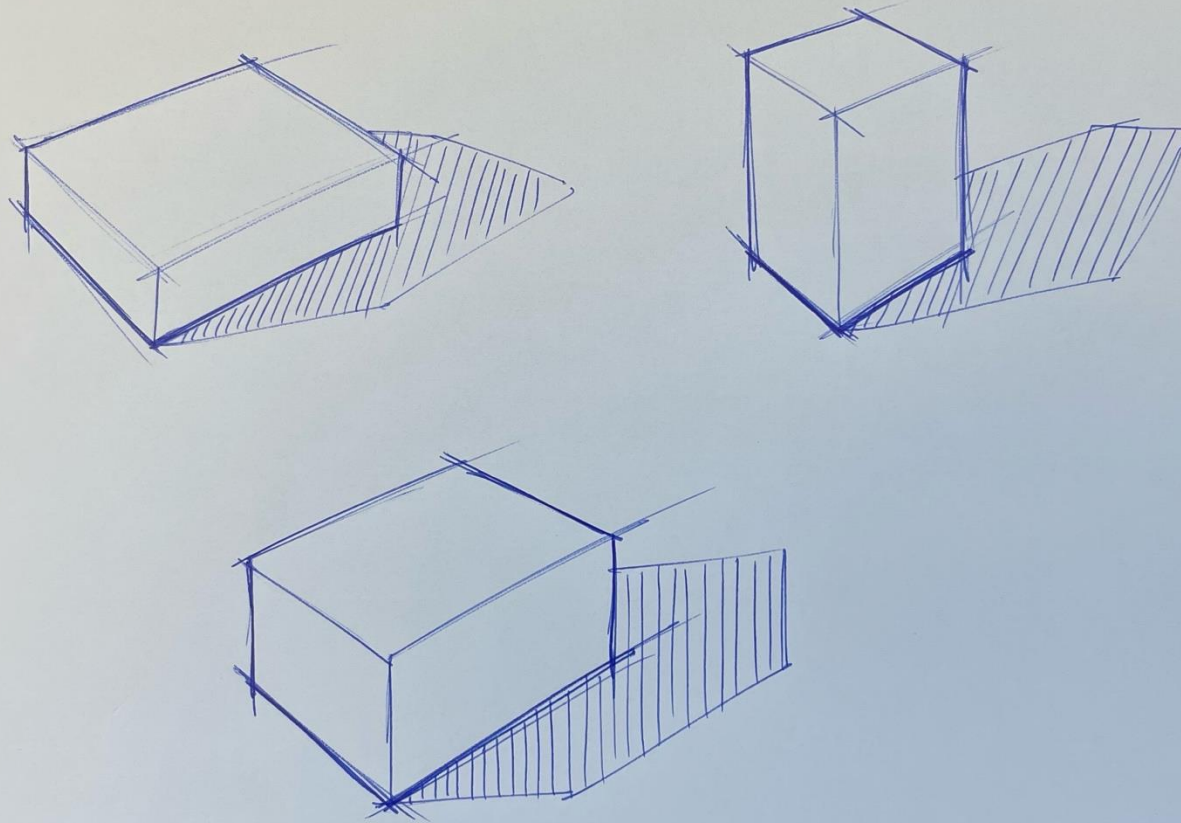
Product Design

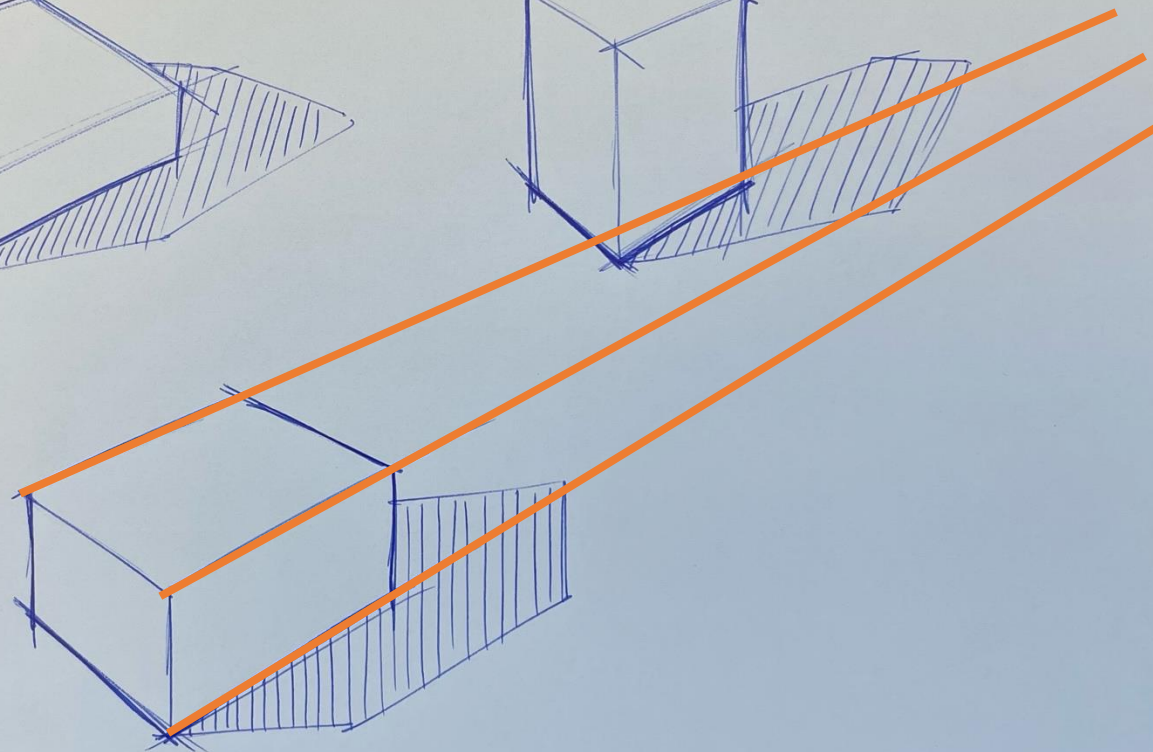
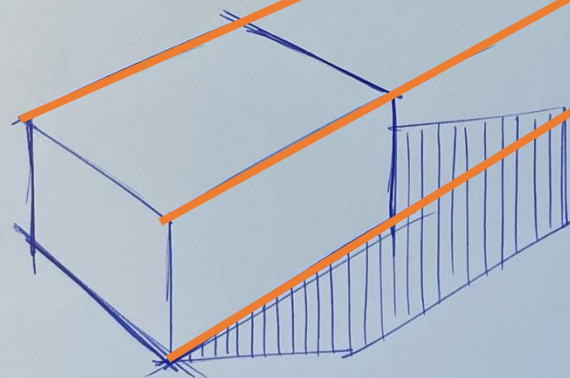
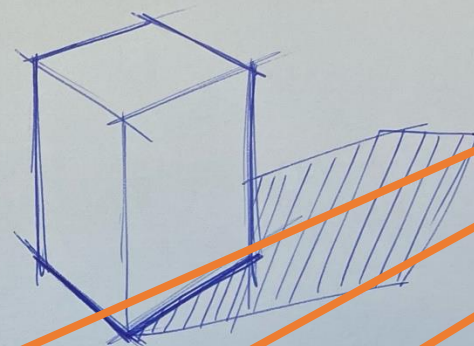
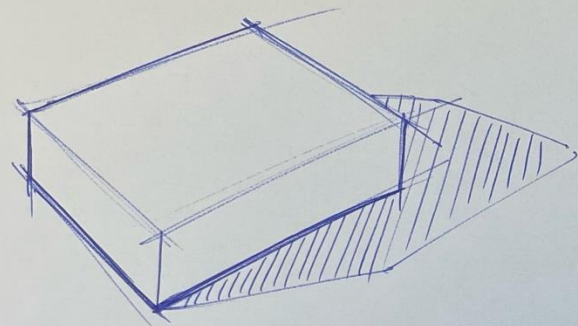
Christopher A. Mattson, PhD
BRIGHAM YOUNG UNIVERSITY

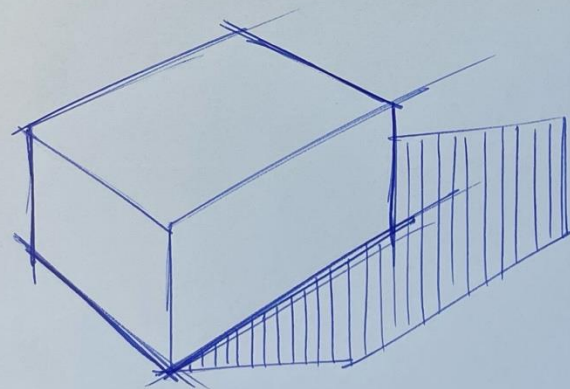
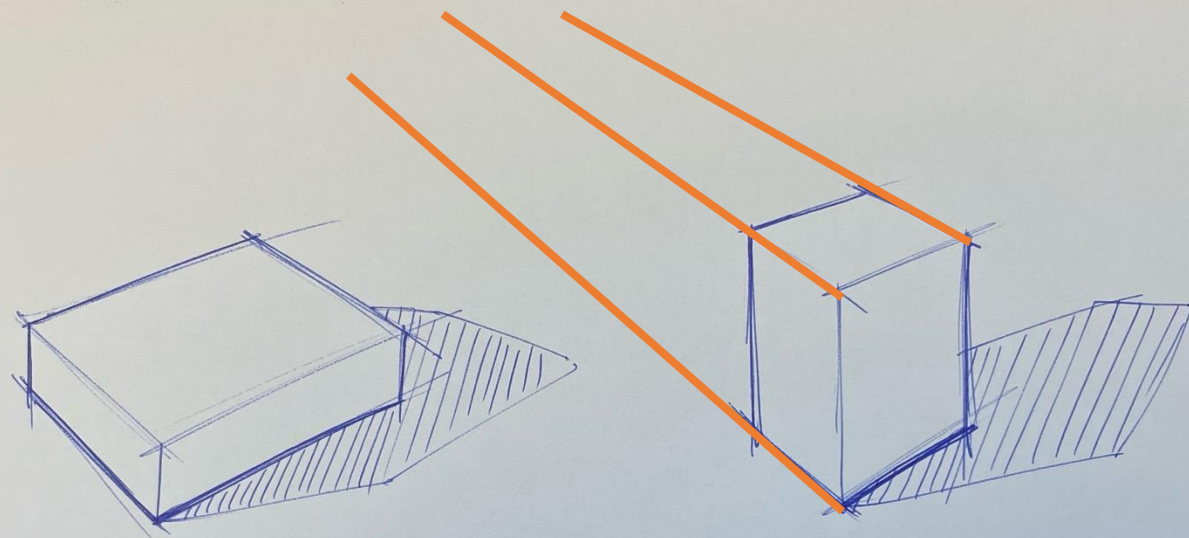


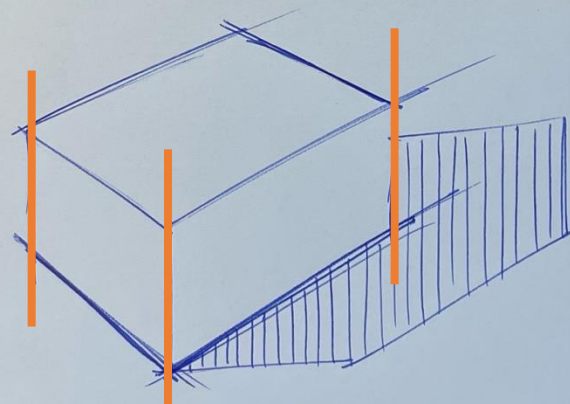
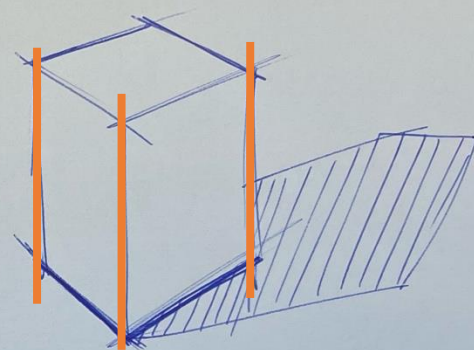
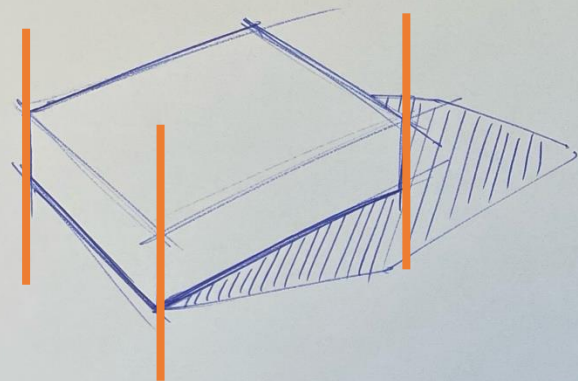
**DESIGN
EXPLORATION
RESEARCH
GROUP**

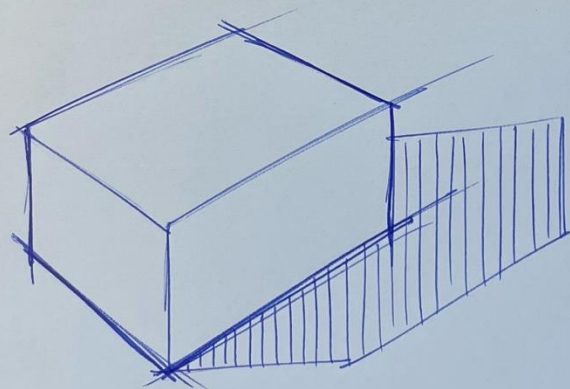
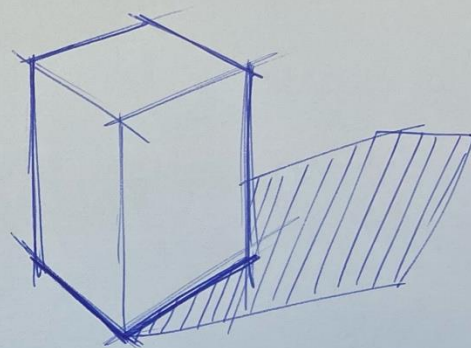
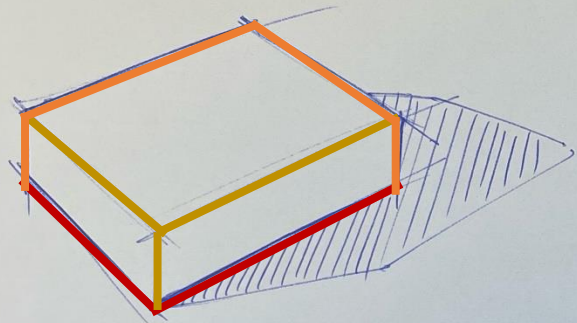
Sketch three cubes with shadows, 3-minutes in total

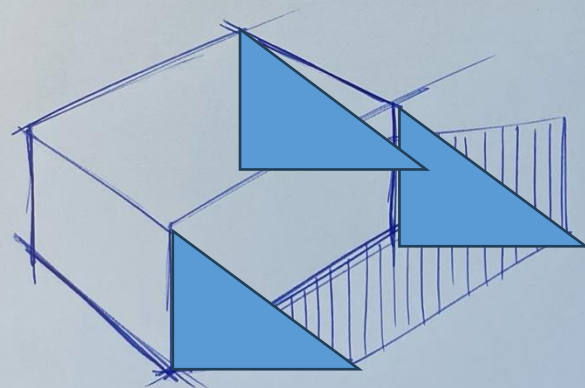
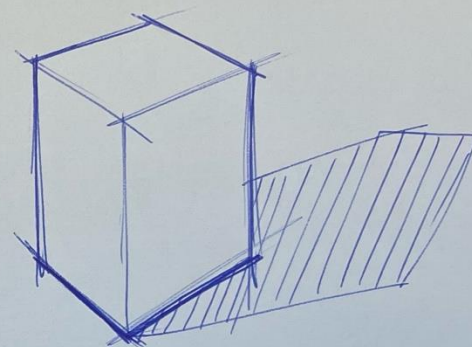
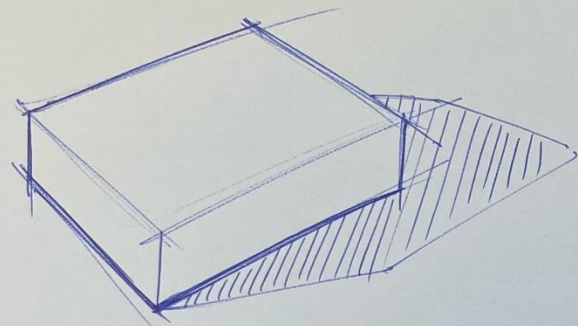


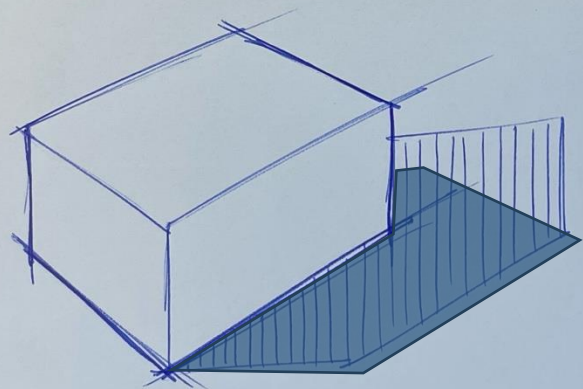
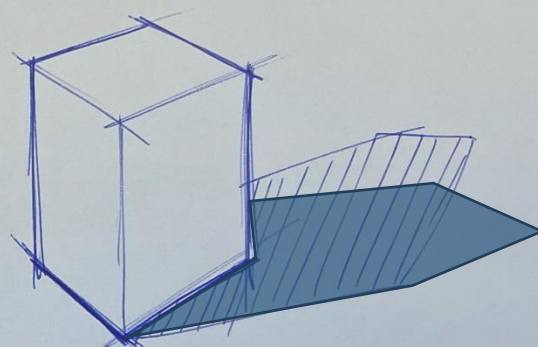
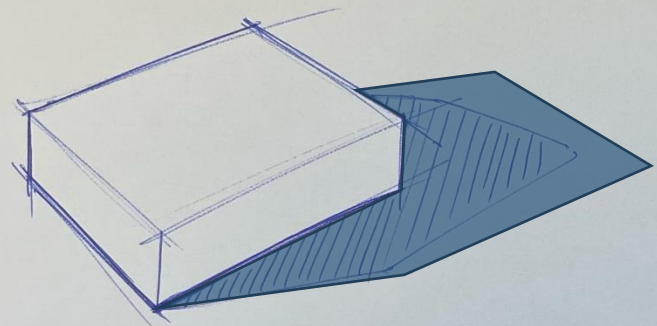














The Role of the Product/Engineering Designer

Week 1: First Lecture

Design is a responsibility, not just a technical task

Product Design

Christopher A. Mattson, PhD
BRIGHAM YOUNG UNIVERSITY



**DESIGN
EXPLORATION
RESEARCH
GROUP**

Outline

- **Pre-class sketching** (5 min, always presented)
- **Business** (13 min)
- **Insights from Reading** (8 min)
- **Design Tools** (20 min)
- **Sketching** (8 min)
- **Designette** (20 min)
- **Closing** (2 min)

Business

	Su	M	T	W	Th	F	S	
Week 0								Design Philosophy & Engineering Design Essentials
Week 1			L	D	L			
Week 2			L	D	L			Complete Opportunity Development -- Initiate
Week 3			L	D	L			
Week 4			L	D	L			Complete Opportunity Development – User Insights
Week 5			L	D	L			
Week 6			L	D	L			Complete Concept Development
Week 7			L	D	L			
Week 8			L	D	L			
Week 9			L	D	L			Complete Sub-System Engineering
Week 10			L	D	L			
Week 11			L	D	L			Complete System Refinement
Week 12			L	D	L			Complete Product Pitch
Week 13			L					
Final Exam								Design Portfolio Due as Final Exam



1.1 Study Plan

Day	Task	Expected Time
M	1. Prepare yourself by completing and internalizing the readings (Sec. 1.2)	62 minutes
	2. Complete and digitally submit the Weekly Reading Response	20 minutes
	3. Complete the daily sketching exercise (Sec. 1.3)	10 minutes
T	1. Attend and be engaged in the class period	75 minutes
	2. Advance your design project inspired by this week's learning (Sec. 1.5)	30 minutes
	3. Complete daily sketching exercise (Sec. 1.3)	10 minutes
W	1. Complete the designette (Sec. 1.4)	60 minutes
	2. Advance your design project inspired by this week's learning (Sec. 1.5)	30 minutes
	3. Identify gaps in understanding and prepare for lecture Q&A	10 minutes
	4. Complete daily sketching exercise (Sec. 1.3)	10 minutes
Th	1. Bring the completed Designette to class for informal review and discussion; attend and be engaged in the class period	75 minutes
	2. Advance your design project inspired by this week's learning (Sec. 1.5)	30 minutes
	3. Complete daily sketching exercise (Sec. 1.3)	10 minutes
F	1. Advance your design project inspired by this week's learning (Sec. 1.5)	60 minutes
	2. Complete daily sketching exercise (Sec. 1.3)	10 minutes
Sa	1. Digitally submit the Designette and the required, ungraded Design Opportunity Framing Page	15 minutes
		Total: 8 h 37 m

Business

Sketchbooks vs Class notes

Visualization Exercise

How to get an A in this class

Individual vs Team Projects

Questions?

Reading Insights

Design is a responsibility, not just a technical task

What did you learn from the readings about design as a responsibility?

What did you learn from the readings about design as a technical task?

“Responsible design” versus “Technical desirability”,
which is most important?

Design Tools

To add to your toolbox

How to be an effective designer

Rick Rubin

Record Producer

Run DMC

LL Cool J

Beastie Boys

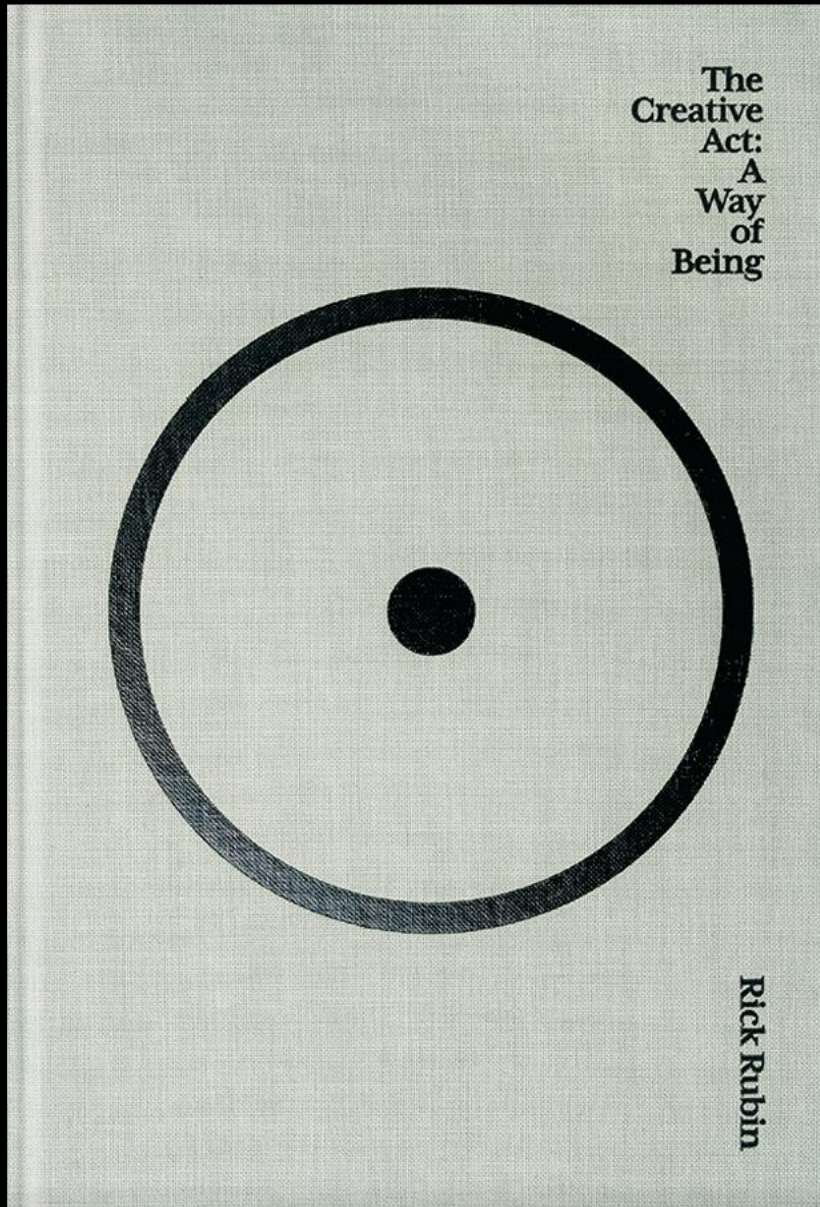
Johnny Cash

Red Hot Chilli Peppers

Ed Sheeran

Adelle





“No matter what tools you use to create, **the true instrument is you**. And through you, the universe that surrounds us all comes into focus.”

Rick Rubin

Decomposition

A universal design tool

11.14 Decomposition

Solve difficult problems one piece at a time

Decomposition – or the act of breaking something down into simpler constituents – is a universal design tool, used in nearly every design project. We can use decomposition to break down a complex project, a complex product, and complex functions. Such breakdowns make it possible for the product development team to attack smaller more manageable design sub-problems.

The need for decomposition varies but includes the fact that different expertise may be required to develop each subsystem, or that the project schedule is tight and requires parallel development in order to complete the project on time.

How to do it

Structural decomposition

The easiest strategy to understand is Structural Decomposition. Structural decomposition is the act of breaking down a product into its structural or physical parts. For example, consider a bicycle. It can be structurally broken down into (i) a welded frame, (ii) wheels, (iii) seat, (iv) handlebars, (v) fork, and (vi) drive train.

Structural decomposition is a valuable activity when a basic structure/concept already exists. If developing a new bicycle for a traditional bicycle market, structural decomposition is a good place to start because the traditional market will expect wheels, seats, handlebars, and so on in a new bicycle. With such a decomposition it is easier for the development team to decide which parts it will purchase off-the-shelf (drive train, for example) and which part it will develop a new design for (welded frame, for example).

Structural decomposition also facilitates project management, as part numbering, document control, development assignments, and so on are often made according to the basic physical parts of the product.

Functional decomposition

A more abstract (less tied to a specific structure or concept) decomposition strategy is functional decomposition. Functional decomposition is the act of dividing the top-level function into simpler subfunctions.

Again considering the bicycle, the top-level function is human transportation. To achieve such function, subfunctions include: (i) structural (hold everything together), (ii) contact ground, (iii) support rider, (iv) rider control, (v) power vehicle, and (vi) esthetics.

Functional decomposition is a valuable activity when there is no established concept or preconceived structure. It's a powerful way to abstract to the essence the problem being solved. When this decomposition is made explicit, it can greatly facilitate the development process as it provides significant design freedom because it is not tied to a specific structure. Notice, for example, that any human-controlled ground vehicle could result from a development project based on this functional decomposition – not merely a bicycle.

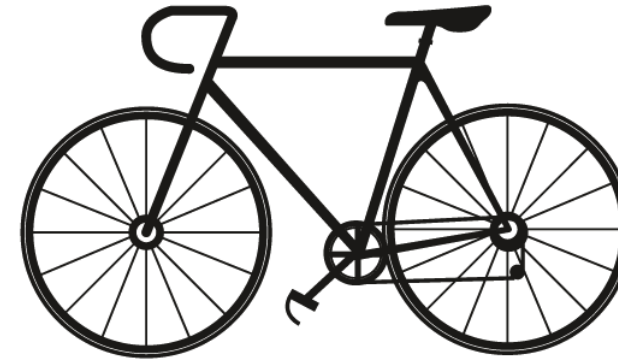
See also

Development Reference: Concept Classification Tree (11.9), Recombination Table (11.53).

Further Reading

Ulrich KT, Eppinger SD (2012) Product design and development, 5th ed. McGraw Hill, New York. pp. 121-123.

Herrmann JW (2004) Decomposition in product development, TSR 2004-6. Institute for Systems Research, University of Maryland.



Structural Decomposition

Welded Frame

Wheels (hub, spokes, rim, tube, tire)

Seat

Handle Bars

Drive Train

Fork

Functional Decomposition

Structure

Contact Ground

Support Rider

Rider Control

Power Vehicle

Aesthetics

Structural and functional decomposition for bicycle.

Christopher A. Mattson · Carl D. Sorensen

Product Development

Principles and Tools for Creating Desirable and Transferable Designs

11.14 Decomposition

Solve difficult problems one piece at a time

Decomposition – or the act of breaking something down into simpler constituents – is a universal design tool, used in nearly every design project. We can use decomposition to break down a complex project, a complex product, and complex functions. Such breakdowns make it possible for the product development team to attack smaller more manageable design sub-problems.

The need for decomposition varies but includes the fact that different expertise may be required to develop each subsystem, or that the project schedule is tight and requires parallel development in order to complete the project on time.

How to do it

Structural decomposition

The easiest strategy to understand is Structural Decomposition. Structural decomposition is the act of breaking down a product into its structural or physical parts. For example, consider a bicycle. It can be structurally broken down into (i) a welded frame, (ii) wheels, (iii) seat, (iv) handlebars, (v) fork, and (vi) drive train.

Structural decomposition is a valuable activity when a basic structure/concept already exists. If developing a new bicycle for a traditional bicycle market, structural decomposition is a good place to start because the traditional market will expect wheels, seats, handlebars, and so on in a new bicycle. With such a decomposition it is easier for the development team to decide which parts it will purchase off-the-shelf (drive train, for example) and which part it will develop a new design for (welded frame, for example).

Structural decomposition also facilitates project management, as part numbering, document control, development assignments, and so on are often made according to the basic physical parts of the product.

Functional decomposition

A more abstract (less tied to a specific structure or concept) decomposition strategy is functional decomposition. Functional decomposition is the act of dividing the top-level function into simpler subfunctions.

Again considering the bicycle, the top-level function is human transportation. To achieve such function, subfunctions include: (i) structural (hold everything together), (ii) contact ground, (iii) support rider, (iv) rider control, (v) power vehicle, and (vi) esthetics.

Functional decomposition is a valuable activity when there is no established concept or preconceived structure. It's a powerful way to abstract to the essence the problem being solved. When this decomposition is made explicit, it can greatly facilitate the development process as it provides significant design freedom because it is not tied to a specific structure. Notice, for example, that any human-controlled ground vehicle could result from a development project based on this functional decomposition – not merely a bicycle.

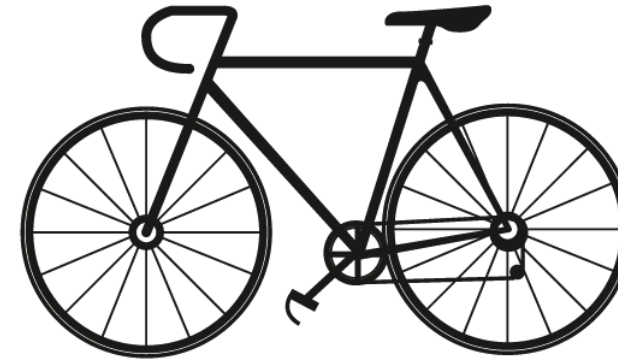
See also

Development Reference: Concept Classification Tree (11.9), Recombination Table (11.53).

Further Reading

Ulrich KT, Eppinger SD (2012) Product design and development, 5th ed. McGraw Hill, New York. pp. 121-123.

Herrmann JW (2004) Decomposition in product development, TSR 2004-6. Institute for Systems Research, University of Maryland.



Structural Decomposition

Welded Frame

Wheels (hub, spokes, rim, tube, tire)

Seat

Handle Bars

Drive Train

Fork

Functional Decomposition

Structure

Contact Ground

Support Rider

Rider Control

Power Vehicle

Aesthetics

Solve difficult problems one piece at a time

Decomposition – or the act of breaking something down into simpler constituents – is a universal design tool, used in nearly every design project. We can use decomposition to break down a complex project, a complex product, and complex functions. Such breakdowns make it possible for the product development team to attack smaller more manageable design sub-problems.

11.14 Decomposition

Solve difficult problems one piece at a time

Decomposition – or the act of breaking something down into simpler constituents – is a universal design tool, used in nearly every design project. We can use decomposition to break down a complex project, a complex product, and complex functions. Such breakdowns make it possible for the product development team to attack smaller more manageable design sub-problems.

The need for decomposition varies but includes the fact that different expertise may be required to develop each subsystem, or that the project schedule is tight and requires parallel development in order to complete the project on time.

How to do it

Structural decomposition

The easiest strategy to understand is Structural Decomposition. Structural decomposition is the act of breaking down a product into its structural or physical parts. For example, consider a bicycle. It can be structurally broken down into (i) a welded frame, (ii) wheels, (iii) seat, (iv) handlebars, (v) fork, and (vi) drive train.

Structural decomposition is a valuable activity when a basic structure/concept already exists. If developing a new bicycle for a traditional bicycle market, structural decomposition is a good place to start because the traditional market will expect wheels, seats, handlebars, and so on in a new bicycle. With such a decomposition it is easier for the development team to decide which parts it will purchase off-the-shelf (drive train, for example) and which part it will develop a new design for (welded frame, for example).

Structural decomposition also facilitates project management, as part numbering, document control, development assignments, and so on are often made according to the basic physical parts of the product.

Functional decomposition

A more abstract (less tied to a specific structure or concept) decomposition strategy is functional decomposition. Functional decomposition is the act of dividing the top-level function into simpler subfunctions.

Again considering the bicycle, the top-level function is human transportation. To achieve such function, subfunctions include: (i) structural (hold everything together), (ii) contact ground, (iii) support rider, (iv) rider control, (v) power vehicle, and (vi) esthetics.

Functional decomposition is a valuable activity when there is no established concept or preconceived structure. It's a powerful way to abstract to the essence the problem being solved. When this decomposition is made explicit, it can greatly facilitate the development process as it provides significant design freedom because it is not tied to a specific structure. Notice, for example, that any human-controlled ground vehicle could result from a development project based on this functional decomposition – not merely a bicycle.

See also

Development Reference: Concept Classification Tree (11.9), Recombination Table (11.53).

Further Reading

Ulrich KT, Eppinger SD (2012) Product design and development, 5th ed. McGraw Hill, New York. pp. 121-123.

Herrmann JW (2004) Decomposition in product development, TSR 2004-6. Institute for Systems Research, University of Maryland.



Structural Decomposition

- Welded Frame
- Wheels (hub, spokes, rim, tube, tire)
- Seat
- Handle Bars
- Drive Train
- Fork

Functional Decomposition

- Structure
- Contact Ground
- Support Rider
- Rider Control
- Power Vehicle
- Aesthetics

Structural decomposition

The easiest strategy to understand is Structural Decomposition. Structural decomposition is the act of breaking down a product into its structural or physical parts. For example, consider a bicycle. It can be structurally broken down into (i) a welded frame, (ii) wheels, (iii) seat, (iv) handlebars, (v) fork, and (vi) drive train.

Structural decomposition is a valuable activity when a basic structure/concept already exists. If developing a new bicycle for a traditional bicycle market, structural

Functional decomposition

A more abstract (less tied to a specific structure or concept) decomposition strategy is functional decomposition. Functional decomposition is the act of dividing the top-level function into simpler subfunctions.

Again considering the bicycle, the top-level function is human transportation. To achieve such function, subfunctions include: (i) structural (hold everything together), (ii) contact ground, (iii) support rider, (iv) rider control, (v) power vehicle, and (vi) esthetics.

Functional decomposition is a valuable activity when there is no established concept or preconceived structure. It's a powerful way to abstract to the essence the problem being solved. When this decomposition is made explicit, it can greatly facilitate the

Structural decomposition also facilitates project management, as part numbering, document control, development assignments, and so on are often made according to the basic physical parts of the product.

Functional decomposition

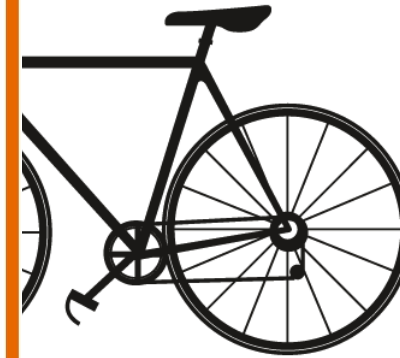
A more abstract (less tied to a specific structure or concept) decomposition strategy is functional decomposition. Functional decomposition is the act of dividing the top-level function into simpler subfunctions.

Again considering the bicycle, the top-level function is human transportation. To achieve such function, subfunctions include: (i) structural (hold everything together), (ii) contact ground, (iii) support rider, (iv) rider control, (v) power vehicle, and (vi) esthetics.

Functional decomposition is a valuable activity when there is no established concept or preconceived structure. It's a powerful way to abstract to the essence the problem being solved. When this decomposition is made explicit, it can greatly facilitate the development process as it provides significant design freedom because it is not tied to a specific structure. Notice, for example, that any human-controlled ground vehicle could result from a development project based on this functional decomposition – not merely a bicycle.

See also

Development Reference: Concept Classification Tree (11.9), Recombination Table (11.53).



Functional Decomposition

Structure
Contact Ground
Support Rider
Rider Control
Power Vehicle
Aesthetics

Fork

Structural and functional decomposition for bicycle.

Decompose the chair you're sitting in

(1 min)







Recombination

A systematic and convenient way to integrate sub systems

11.53 Recombination Table

Combine subconcepts to create hundreds of alternatives

Recombination tables are used to combine subfunction concepts together into full-function (full-system) concepts. One of the table's strengths is the large number of full-function concepts that can emerge. While not all emerging concepts will be feasible, the table makes it possible to explore the design space in a systematic and likely more thorough way. The table can also facilitate concept exploration activities as it helps the team visualize how well distributed across subfunctions the concept exploration has been.

Parts of the recombination table

The leftmost column of the table lists the subfunctions that a product needs to meet. These often come directly from a functional decomposition (see Decomposition). In each row of the table, corresponding to the subfunction, concepts are listed in the columns. It's not necessary that an equal number of subfunction concepts be generated for each subfunction.

Example

Consider a bicycle-like device for transporting humans. The required subfunctions are listed in the table. Now, concepts are generated for each subfunction. For example, the first subfunction listed is *power vehicle*. Various concepts for meeting this function include human power, internal combustion engine, electric motor, and human-electric hybrid.

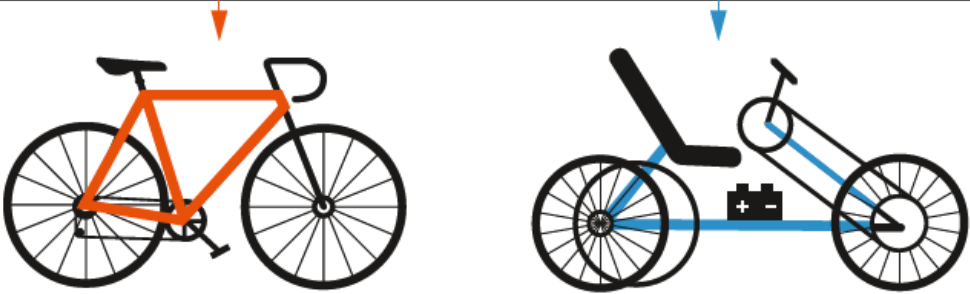
Facilitated by the table, the team can now perform the recombination by simply picking a concept for one subsystem and combining it with one from all of the other subconcepts. The team can do this by intuitively picking concepts that seem compatible or otherwise worth exploring. Or the team can do this in an automated way, where every possible combination is made.

The maximum number of unique combinations is the number of concepts for subfunction one times the number of concepts for subfunction two, and so on. For this bicycle example, there are a total of 192 full-function (full-system) concepts.

See also

Development Reference: Decomposition (11.14).

Functions	Subfunction Concepts			
Power Vehicle	Human Powered	Gas Motor	Electric Motor	Human-electric Hybrid
Support Rider	Small Seat	Banana Seat	Bucket Seat	Suspended Hammock
Contact Ground	1 Wheel	2 Wheels	3 Wheels	4 Wheels
Aesthetic	Orange	Yellow	Blue	
...				



Recombination Table for Bicycle Example.

11.53 Recombination Table

Combine subconcepts to create hundreds of alternatives

Recombination tables are used to combine subfunction concepts together into full-function (full-system) concepts. One of the table's strengths is the large number of full-function concepts that can emerge. While not all emerging concepts will be feasible, the table makes it possible to explore the design space in a systematic and likely more thorough way. The table can also facilitate concept exploration activities as it helps the team visualize how well distributed across subfunctions the concept exploration has been.

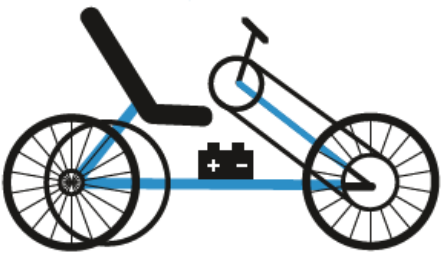
Parts of the recombination table

The leftmost column of the table lists the subfunctions that a product needs to meet. These often come directly from a functional decomposition (see Decomposition). In each row of the table, corresponding to the subfunction, concepts are listed in the columns. It's not necessary that an equal number of subfunction concepts be generated for each subfunction.

Example

Consider a bicycle-like device for transporting humans. The required subfunctions are listed in the table. Now, concepts are generated for each subfunction. For example, the first subfunction listed is *power vehicle*. Various concepts for meeting this function include human power, internal combustion engine, electric motor, and human-electric hybrid.

Functions	Subfunction Concepts			
Power Vehicle	Human Powered	Gas Motor	Electric Motor	Human-electric Hybrid
Support Rider	Small Seat	Banana Seat	Bucket Seat	Suspended Hammock
Contact Ground	1 Wheel	2 Wheels	3 Wheels	4 Wheels
Aesthetic	Orange	Yellow	Blue	
...				



Combine subconcepts to create hundreds of alternatives

Recombination tables are used to combine subfunction concepts together into full-function (full-system) concepts. One of the table's strengths is the large number of full-function concepts that can emerge. While not all emerging concepts will be feasible, the table makes it possible to explore the design space in a systematic and likely more thorough way. The table can also facilitate concept exploration activities as it helps the team visualize how well distributed across subfunctions the concept exploration has been.

11.53 Recombination Table

Combine subconcepts to create hundreds of alternatives

Recombination tables are used to combine subfunction concepts together into full-function (full-system) concepts. One of the table's strengths is the large number of full-function concepts that can emerge. While not all emerging concepts will be feasible, the table makes it possible to explore the design space in a systematic and likely more thorough way. The table can also facilitate concept exploration activities as it helps the team visualize how well distributed across subfunctions the concept exploration has been.

Parts of the recombination table

The leftmost column of the table lists the subfunctions that a product needs to meet. These often come directly from a functional decomposition (see Decomposition). In each row of the table, corresponding to the subfunction, concepts are listed in the columns. It's not necessary that an equal number of subfunction concepts be generated for each subfunction.

Example

Consider a bicycle-like device for transporting humans. The required subfunctions are listed in the table. Now, concepts are generated for each subfunction. For example, the first subfunction listed is *power vehicle*. Various concepts for meeting this function include human power, internal combustion engine, electric motor, and human-electric hybrid.

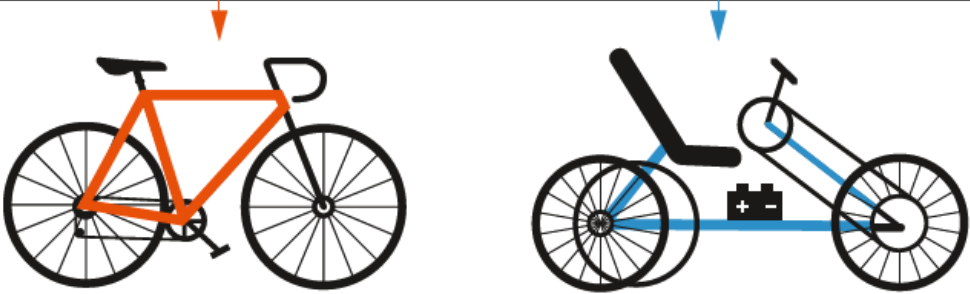
Facilitated by the table, the team can now perform the recombination by simply picking a concept for one subsystem and combining it with one from all of the other subconcepts. The team can do this by intuitively picking concepts that seem compatible or otherwise worth exploring. Or the team can do this in an automated way, where every possible combination is made.

The maximum number of unique combinations is the number of concepts for subfunction one times the number of concepts for subfunction two, and so on. For this bicycle example, there are a total of 192 full-function (full-system) concepts.

See also

Development Reference: Decomposition (11.14).

Functions	Subfunction Concepts			
Power Vehicle	Human Powered	Gas Motor	Electric Motor	Human-electric Hybrid
Support Rider	Small Seat	Banana Seat	Bucket Seat	Suspended Hammock
Contact Ground	1 Wheel	2 Wheels	3 Wheels	4 Wheels
Aesthetic	Orange	Yellow	Blue	
...				



Recombination Table for Bicycle Example.

Use Recombination Table

Functions	Subfunction Concepts			
Power Vehicle	Human Powered	Gas Motor	Electric Motor	Human-electric Hybrid
Support Rider	Small Seat	Banana Seat	Bucket Seat	Suspended Hammock
Contact Ground	1 Wheel	2 Wheels	3 Wheels	4 Wheels
Aesthetic	Orange	Yellow	Blue	
...				



Now Sketch a Concept from the Recombination Table

6 minutes

MCM

Most Critical Module



MCI

Most Critical Interface

How Design Works

What does and should be happening in our heads?

Geometry | Material | Processing

A triad of design decisions

wood



aluminum



plastic



foam



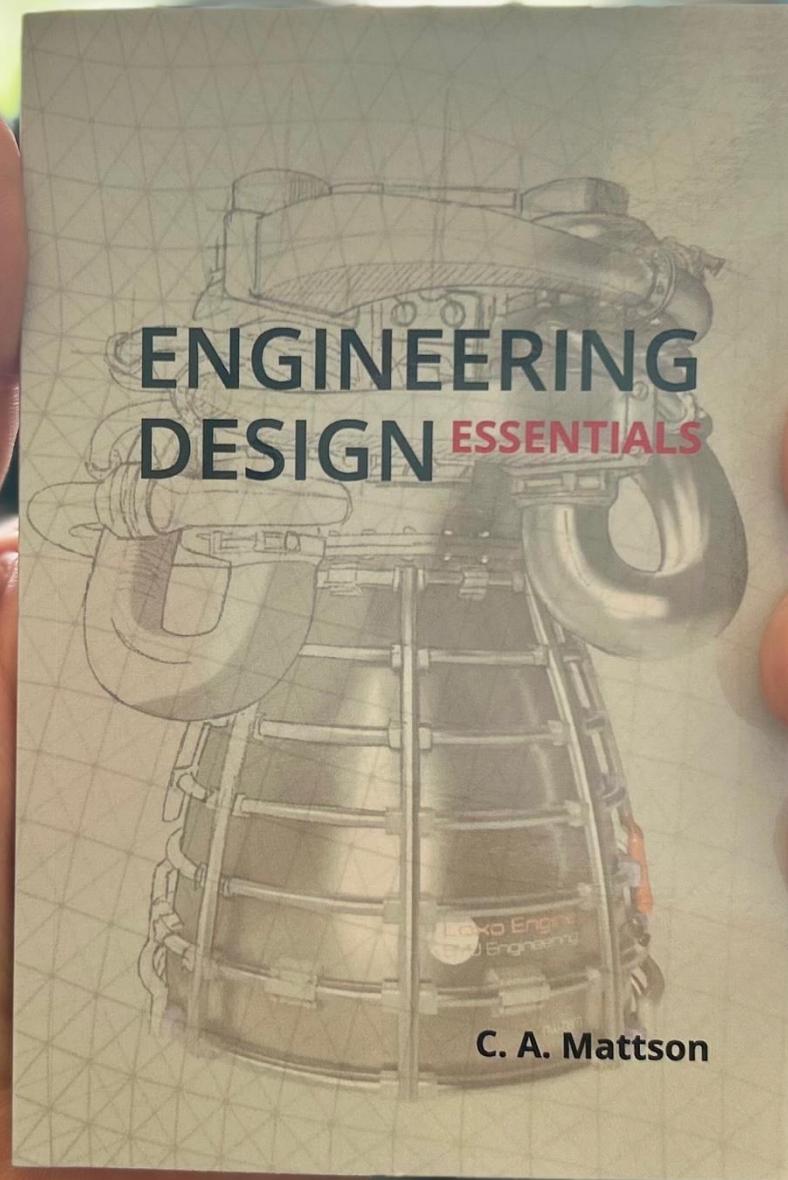
glass

?

Sketch a Functional Glass Baseball Bat

(2 min, side view)

● Go to Page 15



Turn today's teachings into design principles

Write at least one on a piece of paper
(1 min)

1. All projects, products, and problems can be broken down into constituent parts; doing so makes them easier to work on/solve.
2. Systematic recombination of sub systems leads to numerous system-level ideas.
3. The interfaces between subsystems are critical to system desirability.
4. When designing parts, geometry, material, and processing decisions should not be made in isolation.

Designette

A short, focused design challenge

Designette (11 minutes)

Subject: Milwaukee Fastback Utility Knife

Purpose: To carefully observe, use sketching as a tool for seeing, and make the connection between mechanical design decisions and their broader human impacts.

Tasks:

1. Look carefully at the knife's form, function, and behavior.
2. Spend 3 minutes writing down five specific, non-obvious observations about the object. Avoid vague value judgments – just describe what you see.
3. Spend 5 minutes sketching the knife. Annotate your sketch with at least two of your observations to highlight interesting or important details.
4. 3 minutes: write one design insight or question that your sketch helped you see. Focus on a specific design decision – such as how the knife folds, how the blade is exposed, or how the user grips the tool. What might be the consequence of that choice for the user's safety, experience, or long-term use?



Closing

You are the instrument

Principles and Tools Become Part of your design philosophy

You must practice and strengthen before you can serve



1.1 Study Plan

Day	Task	Expected Time
M	1. Prepare yourself by completing and internalizing the readings (Sec. 1.2)	62 minutes
	2. Complete and digitally submit the Weekly Reading Response	20 minutes
	3. Complete the daily sketching exercise (Sec. 1.3)	10 minutes
T	1. Attend and be engaged in the class period	75 minutes
	2. Advance your design project inspired by this week's learning (Sec. 1.5)	30 minutes
	3. Complete daily sketching exercise (Sec. 1.3)	10 minutes
W	1. Complete the designette (Sec. 1.4)	60 minutes
	2. Advance your design project inspired by this week's learning (Sec. 1.5)	30 minutes
	3. Identify gaps in understanding and prepare for lecture Q&A	10 minutes
	4. Complete daily sketching exercise (Sec. 1.3)	10 minutes
Th	1. Bring the completed Designette to class for informal review and discussion; attend and be engaged in the class period	75 minutes
	2. Advance your design project inspired by this week's learning (Sec. 1.5)	30 minutes
	3. Complete daily sketching exercise (Sec. 1.3)	10 minutes
F	1. Advance your design project inspired by this week's learning (Sec. 1.5)	60 minutes
	2. Complete daily sketching exercise (Sec. 1.3)	10 minutes
Sa	1. Digitally submit the Designette and the required, ungraded Design Opportunity Framing Page	15 minutes
		Total: 8 h 37 m