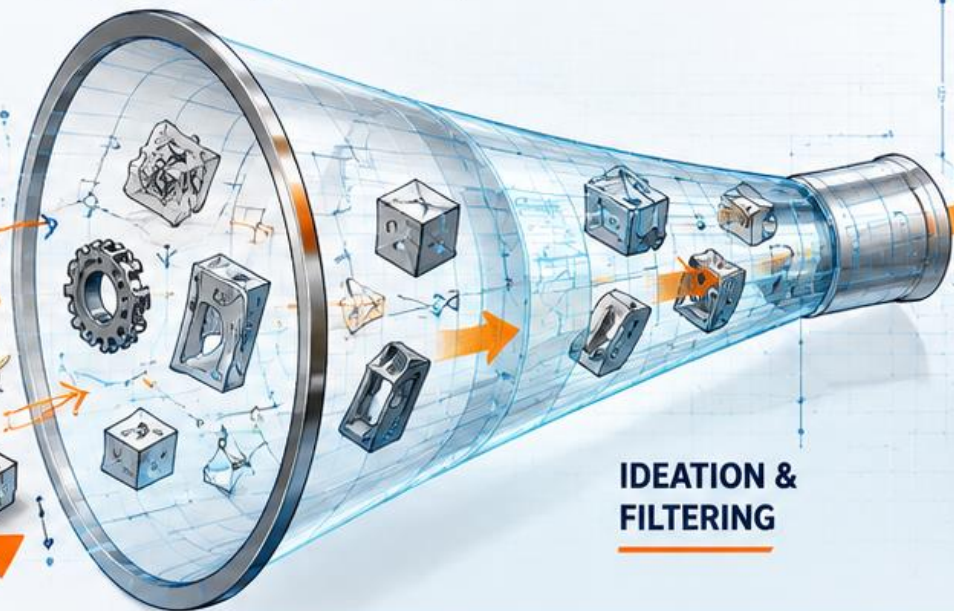


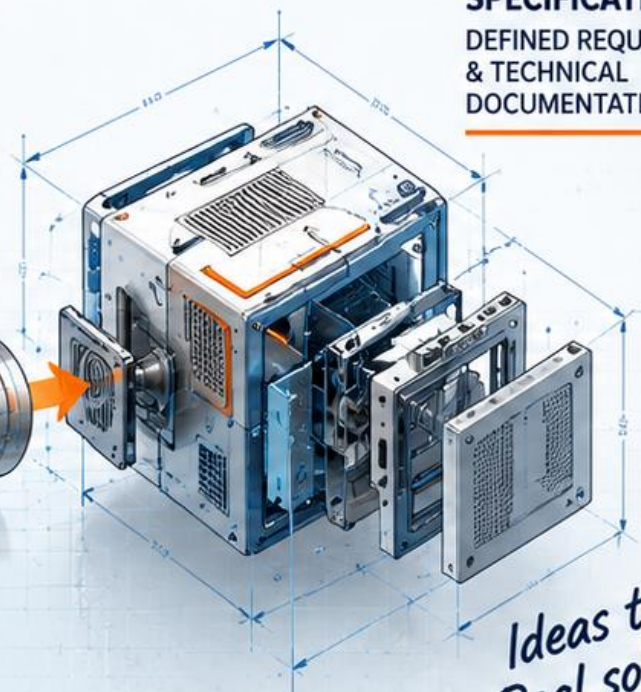
Engineering Project Design: From Ideation to Specification

A structured approach to generating ideas, selecting solutions, and defining technical requirements.

RAW CONCEPTS



SPECIFICATION:
DEFINED REQUIREMENTS
& TECHNICAL
DOCUMENTATION



EXPLORE

Identify problems
and opportunities



GENERATE

Create and develop
ideas



REFINE

Evaluate and
select solutions



DEFINE

Produce technical
specifications



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The Engineer's Roadmap to a Solution

The journey begins with a broad theme or a specific problem provided by a tutor. The goal is to move from a wide range of possibilities to a single, rigorously defined plan.

*Ideas today.
Real solutions
tomorrow.*



01



Define Scope

Identifying Themes & Problems



UNDERSTAND THE NEED

02



Divergence

Generating Ideas & Research



EXPLORE POSSIBILITIES

03



Convergence

Developing Solutions & Specifications



REFINE AND SELECT

04



Review

Evaluation & Technical Check



VALIDATE AND IMPROVE



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Establishing the Scope: Themes vs. Problems

A project often starts with a general theme, from which a suitable, specific problem must be identified.



Typical Project Themes

*Real-world themes.
Real opportunities.*



Power



Energy



Motion



Forces



Security



Wind Turbines



Flight



Propulsion



Your project can sit under any of these themes.
The key is choosing something **realistic, practical and interesting** to you.

Case Study: Inception

SMITHSONS
— EST. 1851 —



The Problem

Smithsons, a legacy watchmaker, identified a problem: they were losing market share.



The Theme

Their "theme" became product modernization in a changing market.



The Opportunity

Move from traditional mechanical watches to modern, fitness-focused digital products.

“Understanding the right problem leads to better, more relevant solutions.”



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Project Possibilities by Engineering Specialism

*Different skills.
Real opportunities.
Your choice.*

Your project can focus on almost any area of engineering. Here are some example ideas to help you get started.



Mechanical

- Design a mechanical system
- **Conveyor** manufacture
- Repair manual for **indexing conveyor**



Manufacturing

- Modify product
- **CNC program** for complex product
- CAD/CAM or **additive machining** assembly



Electrical / Electronic

- Test system/service
- Design **security system** & **PCB manufacture**



Aeronautical

- Modify product/service
- Build **hydraulic rig**
- **Hard landing** maintenance procedure



Computing

- Modify service/**hardware/software**
- **Robotic arm** control program



Mechatronic

- Design **electronic/mechanical**/computer system
- **Greenhouse temperature** control



Automotive

- Modify vehicle part
- **Electronic, braking** or **steering** modification



“Engineering gives you the opportunity to apply your interests to real-world problems.”



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The Research Phase: Gathering Intelligence

Before generating solutions, gather background information. Do not develop a specific plan yet — concentrate on volume and context.

*Good research
leads to
better ideas.*

Engineering research...



Internet

Websites, articles
and trusted sources



Journals

Academic and
industry publications



Libraries

Textbooks, reference
books and reports



Databases

Technical data,
standards and patents



Company Websites

Manufacturer information,
product details and case studies



Case Study: Smithsons Market Analysis

*Research real problems.
Find real opportunities.*



Context

Smithsons moved from
mechanical pocket watches
to **"cheap and cheerful"**
digital watches.



Insight

They identified a
**"boom in sports
and fitness."**



Result

Supplement existing range
with a **fitness-related watch**
rather than competing
in the luxury niche.



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The Creativity Toolkit: Cognitive Reframing

Think differently.
Better ideas.
Greater impact.

Once the problem is chosen, use these cognitive tools to unlock potential solutions.

01 Reword the Problem

Write the problem in different ways to pinpoint the true need.

- ✓ Use different words
- ✓ Look at who, what, when, where, why
- ✓ Identify the real need
- ✓ Avoid assumptions



02 Challenge Assumptions

Look from different perspectives. Just because it's "traditionally done in a certain way" doesn't mean it can't be improved.

- ✓ What do we assume to be true?
- ✓ Who says it has to be that way?
- ✓ How could we do it differently?
- ✓ Consider other industries or users



03 Think in Reverse

Work backward from how the problem arose to stimulate new ideas.

- ✓ Start with the end goal
- ✓ Ask "What would make this fail?"
- ✓ Work backward to find solutions
- ✓ Flip the problem to find new angles



Did you know?

Outsiders often have the most interesting ideas because they lack established assumptions.



A fresh perspective
can lead to breakthrough
solutions.



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The Creativity Toolkit: Visual & Collaborative Methods

*Different people.
Different perspectives.
Better solutions.*

Use these creativity techniques to generate a wide range of ideas and explore different perspectives.

01

Group Discussion / Brainstorming

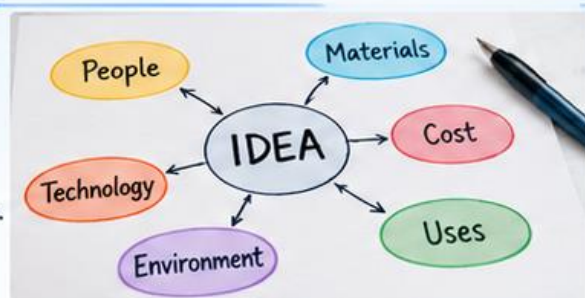
- ✓ Invite experts and 'outsiders' for fresh perspectives.
- ✓ Encourage open and non-judgemental ideas.
- ✓ Build on each other's ideas (no criticism).
- ✓ Aim for quantity, then refine later.



02

Visual Mapping

- ✓ Use diagrams to reveal connections.
- ✓ Explore how ideas link together.
- ✓ Identify related concepts and stakeholders.
- ✓ Helps you see the bigger picture.



03

De Bono's Six Thinking Hats®

- ✓ Generate ideas by "wearing" different perspectives.
- ✓ Helps explore a problem from multiple angles.
- ✓ Reduces group bias.
- ✓ Leads to more balanced and creative solutions.



Example: Visual Map for Problem Solving



The Six Thinking Hats®



White Hat
Facts &
Information



Red Hat
Feelings &
Intuition



Blue Hat
Process &
Control



Green Hat
Creativity &
New Ideas



Yellow Hat
Optimism &
Benefits



Black Hat
Cautions &
Weaknesses

“

*Try putting on the hat that appeals to you least,
and see what ideas you come up with.*



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Theory in Action: The Smithsons Pivot

How research and problem analysis can lead to a strategic decision and a focused project direction.

*Real research.
Real decisions.
Real impact.*



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Convergence: From Many Ideas to One Solution

After generating a wide range of ideas, you must narrow them down to identify the most practical and valuable solution.

*"Filter ideas.
Focus on value.
Turn ideas into
real solutions."*



The Purpose of Specification

A specification helps you pin down what is practical and worth developing. It focuses on products, services, systems or processes that have not yet been designed but could work for the need.

- ✓ Turns ideas into clear requirements
- ✓ Helps compare and select the best option
- ✓ Defines what will be developed
- ✓ Links to performance, cost, materials and user needs



Smithsons Context

Deciding between the Fitness Watch (advanced features) and the Tracker Band (limited data) requires a specification.



Fitness Watch

- Advanced features
- Higher cost
- Wider market appeal
- More complex design

VS



Tracker Band

- Limited data
- Lower cost
- Simpler design
- Niche market



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Anatomy of a Specification: Visuals & Processes

Visualise.
Plan.
Make it real.

A specification brings ideas to life through clear visuals and defined processes.



Graphic Solutions

Use sketches, diagrams, and relevant photos to communicate ideas clearly.



Storyboards

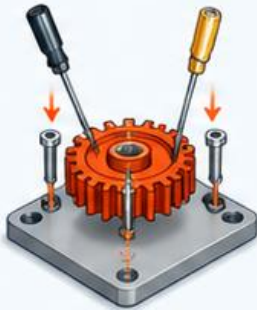
A graphic sequence of events used for planning operations (e.g., CAD modelling or additive manufacturing).

1 Component Preparation



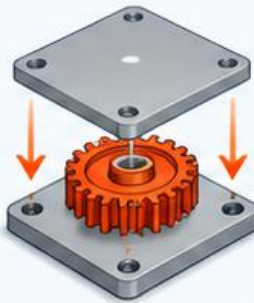
Prepare components and check dimensions.

2 Sub-assembly



Assemble sub-components.

3 Final Assembly

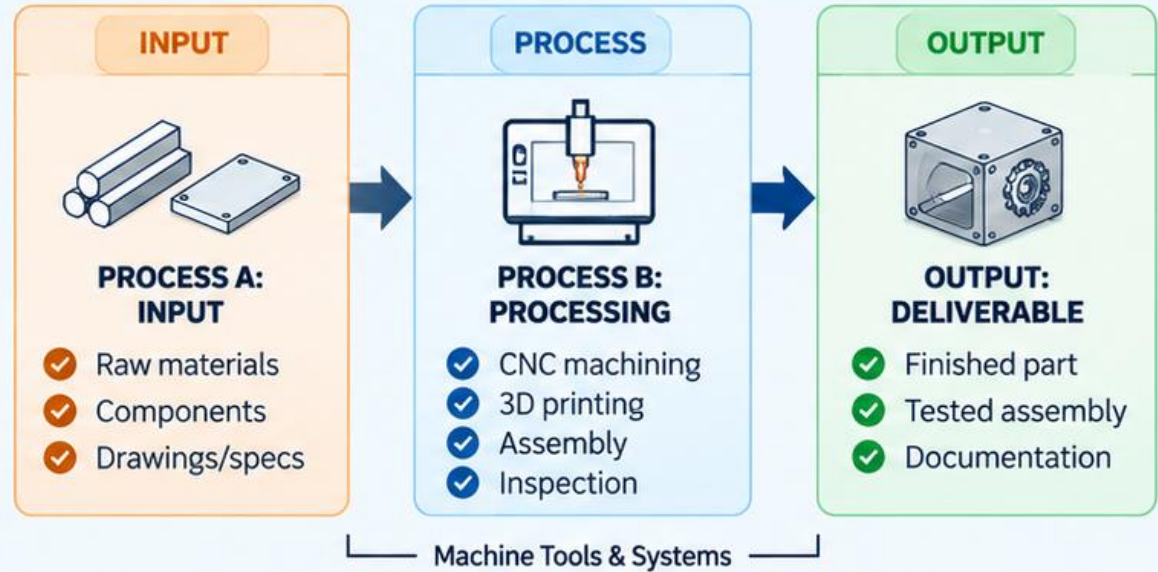


Fit final components and secure.



Process Outlines

Look at the processes within each solution. List machine tools, systems, and assemblies involved.



A clear visual and process outline helps ensure the solution is practical, efficient, and achievable.



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Anatomy of a Specification: Data & Metrics

A good specification is based on realistic data, measurements and performance requirements.

Measure.
Compare.
Make it real.



Rough Costings

Estimate the likely costs for materials, components and manufacturing.

- ✓ Consider the budget.
- ✓ Account for materials and labour.
- ✓ Include tooling, testing and assembly.
- ✓ Draw up a spreadsheet for accuracy.

Item	Quantity	Unit Cost (£)	Total Cost (£)
Display module	1	12.00	12.00
Processor	1	8.50	8.50
Battery	1	4.00	4.00
Case & strap	1	6.00	6.00
Assembly (labour)	1	5.00	5.00
Estimated Total			35.50



Tip: Use a spreadsheet

A spreadsheet helps you update costs easily and check your calculations.



Initial Technical Information

Gather key data about size, mass, materials and other technical details.



Mass (approx.)	45 g
Volume (approx.)	60 cm ³
Case material	Aluminium alloy
Strap material	Silicone rubber
Display	1.3" LCD (33 mm)
Battery capacity	300 mAh
Water resistance	5 ATM (50 m)



Measure
and estimate.



Use standard
units (mm, g, cm³).



List suitable
materials.



Performance Parameters

The capabilities that a system must have in order for it to be successful or to achieve its goals.

- ✓ Measureable and specific (e.g. battery life ≥ 24 hours)
- ✓ Relevant to user needs (e.g. accurate heart rate tracking)
- ✓ Realistic and achievable
- ✓ Used to compare and evaluate design options

**"If you can't measure it,
you can't improve it."**



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Key Technical Terminology

Understanding key terms helps you communicate ideas, develop solutions and write a clear specification.

*Same language.
Bigger ideas.*



Mind Map

A web of thoughts written out on paper or drawn on a computer, with a key word or idea in the centre, linked by lines to related ideas.



Performance Parameters

The capabilities that a system must have in order for it to be successful or to achieve its goals.

Parameter	Example (Fitness Watch)
Battery life	≥ 24 hours
Weight	≤ 50 g
Water resistance	≥ 5 ATM
GPS accuracy	± 3 m
Heart rate accuracy	$\pm 5\%$
Display size	≥ 1.2 inches



- ☒ Measurable
- ☒ Specific
- ☒ Realistic
- ☒ Relevant
- ☒ Used for comparison



Fitness Watch

A watch with advanced features to support sport and fitness activities, such as a heart monitor, workout programmes, a sleep monitor, an accelerometer and GPS; most give immediate on-screen displays of live data.



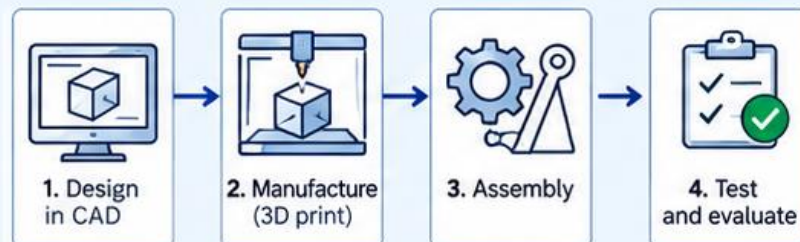
Typical features:

- ☒ Heart rate monitor
- ☒ GPS
- ☒ Workout tracking
- ☒ Sleep monitoring
- ☒ Accelerometer
- ☒ On-screen display
- ☒ Sync with phone/app



Storyboard

A graphic sequence of events used for planning operations, e.g. for 3D modelling on CAD systems or for additive manufacturing.



Trackers Band

A thinner version of a fitness watch, usually limited to keeping track of steps, distance and calories; most trackers can synchronise with your phone, tablet or computer so that you can store and access the data on other devices.



Typical features:

- ☒ Step counter
- ☒ Distance tracking
- ☒ Calories burned
- ☒ Slim and lightweight
- ☒ Syncs with phone/app
- ☒ Long battery life
- ☒ Lower cost

“

Using the correct technical terminology helps you communicate clearly and professionally in your project.



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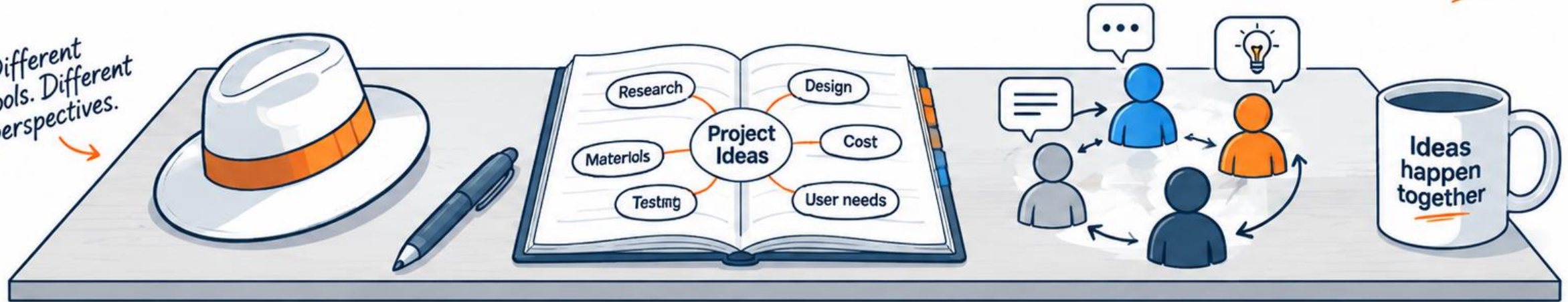
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Discussion: Selecting Your Tools

Different people work in different ways. Which tool is best for your project?

*Different perspectives.
Better solutions.*

Different tools. Different perspectives.



Reflection Questions

- 1 What are the benefits and limitations of each creativity tool?
- 2 Which 'Hat' (De Bono) do you wear most often?
- 3 **Challenge:** Try putting on the hat that appeals to you least, and see what ideas you come up with.



Things to Consider

- ✓ Purpose of the tool
- ✓ How it helps your thinking
- ✓ When it is most useful
- ✓ Any limitations
- ✓ How it fits with your project and team
- ✓ Try a combination of tools



Remember

- ✓ There is no single "right" tool.
- ✓ Different tools suit different situations.
- ✓ A mix of tools often gives the best results.
- ✓ Be open to new ways of thinking.
- ✓ Collaboration can spark new ideas.
- ✓ Choose the tools that help you make progress in your project.



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Project Gate Review: Market & Viability

Use these key questions to assess whether your product idea is commercially viable and worth developing.

*Good ideas
solve real needs.*



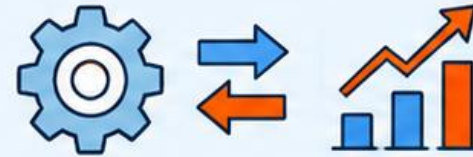
GATE QUESTIONS

Answer these questions to check the market potential and viability of your idea.

1

Market Dynamics

Is technology leading the market, or is the market pushing technology?



Understand what drives the market and where the opportunities are.

2

Lifecycle

How quickly are models replaced? What does 'planned obsolescence' mean?



Consider product lifecycles and how long your design will remain relevant.

3

The Pitch

If you were developing the Smithsons watch, how would you balance desired features against the budget?



Find the right balance between features, performance and cost.

4

Alternatives

Would a mobile phone app be sufficient instead of a hardware device?



Explore alternative solutions and whether existing technology could meet the need.



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From Abstract to Concrete

A simple process to turn a broad theme into a focused solution.

*Big ideas
become real
solutions.*

Theme

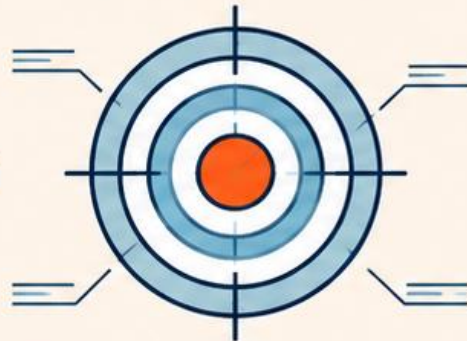
A broad area of interest.



e.g. Health, sustainability,
wearable technology,
smart living.

Problem

A specific need or challenge
within the theme.



e.g. "How can we help people
monitor their fitness easily
and affordably?"

Ideas

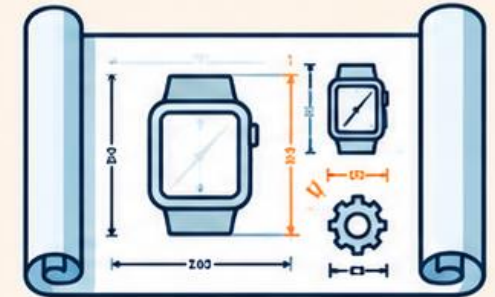
Generate many possible
solutions.



e.g. Brainstorming, mind maps,
reverse thinking, different
perspectives.

Solution

Develop and refine the best idea
into a workable design.



e.g. A fitness tracker with
key features, technical details
and a plan for manufacture.

**You are not developing a specific plan at the start—but by following this process,
you will end with one. Begin your research.**



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Conclusion

From Idea to Engineering Solution

“Engineering design is not simply about having a good idea. It is about developing evidence that the idea can become a workable solution.”



Define

Turn a broad theme into a clear engineering problem.



Explore

Research the context and generate multiple possible solutions.



Converge

Compare ideas against requirements, constraints, cost and feasibility.



Specify

Convert the selected concept into measurable technical requirements.

*Ideas today.
Solutions tomorrow.*



A strong engineer does not jump to the first solution — they **research, question, generate, compare** and **justify**.

Review: Can You Think Like an Engineer?

Test your understanding. Try these questions.

01



Recall

What is the difference between a theme and an engineering problem?

02



Explain

Why should engineers generate several ideas before selecting one?

03



Apply

Your project has excellent performance but costs twice the available budget. Is it a successful solution?

04



Analyse

Why should specification requirements be measurable?

05



Challenge

If your first idea turns out to be the best idea, was generating all the other ideas a waste of time?



Exit Ticket Before you leave, complete these sentences:

1

One thing I understand now...

2

One thing I still need to clarify...

3

One technique I could use in my own Unit 5 project...



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Any Questions?

Before we finish...

What would you like me to explain again?



ASK

Something you are still unsure about.

e.g. a concept, process, term or task from today's lesson.



CHALLENGE

Something you disagree with or want to question.

e.g. an idea, a method, or how something was explained.



APPLY

How could today's learning help with your own Unit 5 project?

e.g. a technique you could use, or a new idea you want to try.

Curious minds build brighter futures.



Ideas Questions Progress

Today's questions can lead to tomorrow's solutions.



No question? Then answer this:

“What is the most important decision an engineer makes between identifying a problem and producing the final specification — and why?”



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