



TeachEngineering

STEM Curriculum for K-12

Fabrication of a Resin Keychain or Key Ring



Subscribe to our newsletter at TeachEngineering.org to stay up-to-date on everything TE!

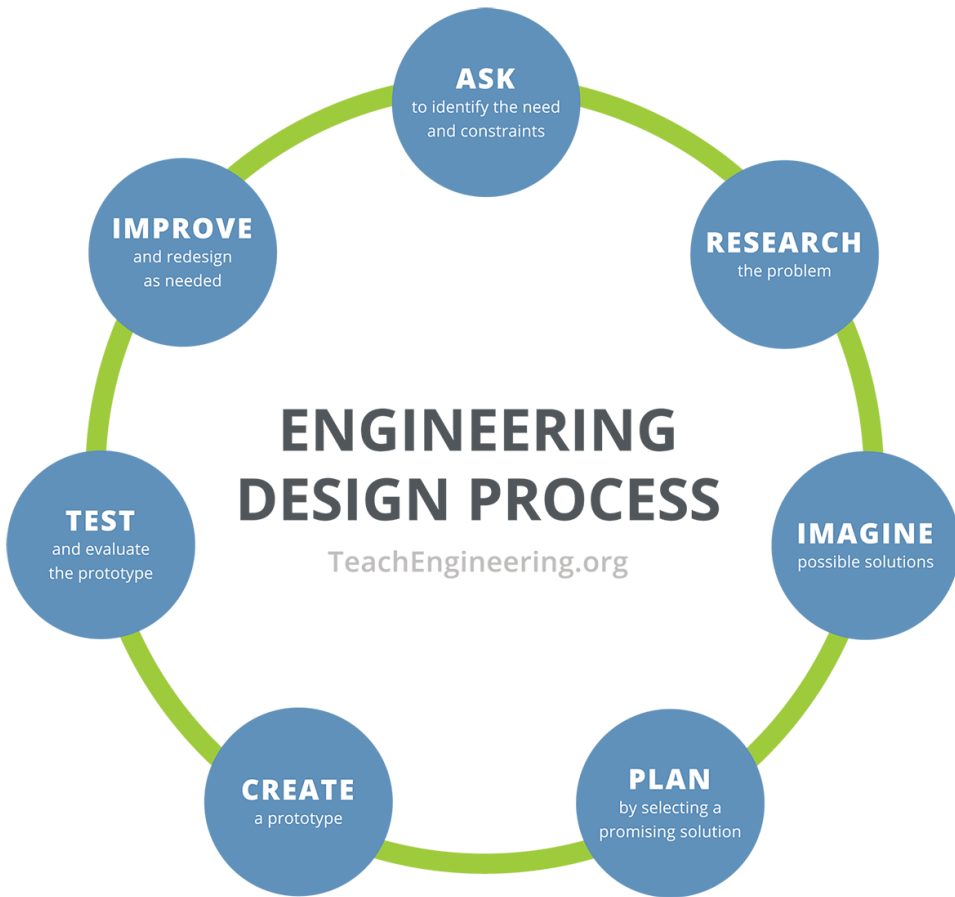
Brought to you by



Engineering – defined

- creative application of **math and science principles** to design or develop structures, machines, apparatus, or manufacturing processes, or actions of using them singly or in combination
- to construct or operate the same objects with full thought about their **design structures** and **functions**
- to predict how objects will behave under specific environmental conditions
- to engineer a design that provides the intended function with consideration given to the cost of operation and safety to life and property

American Engineers' Council for Professional Development. Wikipedia. 2020



Steps in the Engineering Process

Thumbnail Sketch

- quick, abbreviated drawings
- remember important features of a subject

Model

- non-working representation that illustrates product
- may be constructed at any stage in product cycle

Prototype

- full scale working model
- working representation which detect flaws or problems
- occurs in advance of production



Model vs. Prototype



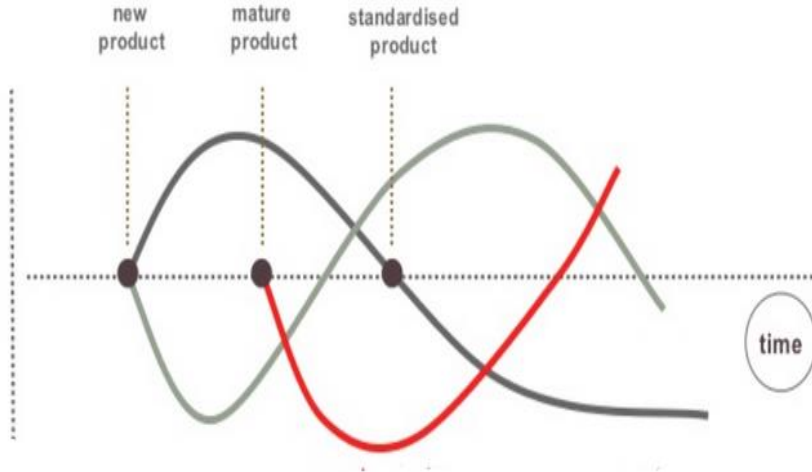
Model

- Not necessarily functional (does not need to work).
- Can be to any scale (usually smaller but can also be of the original size or bigger).
- Used for Display or/and [Visual] Demonstration of product.
- May consist of only the exterior of the object/product it replicates.
- Relatively cheap to manufacture.

Prototype

- Is fully functional, but not fault-proof.
- Is an actual working version of the intended product.
- Used for performance evaluation and further improvement of product.
- Contains complete interior and exterior.
- Is relatively expensive to produce.

Early vs. Late Prototyping Varied Purposes



Early Prototyping

- Evaluates function to solve problem or complete a task
- Determines interface with internal components and external environment

Late Prototyping

- Used to evaluate performance level or process of carrying out or accomplishing an action, task, or function

Throwaway vs. Evolutionary vs. Incremental

“Throw away” (“Rapid Prototyping”)

- Used primarily in requirements gathering
- Low cost with limited quality & functionality

Incremental (Functional)

- Working still needs variables added &/or adjusted to integrate system
- Delivery of prioritized functions incrementally added &/or adjusted to the single, overall design

Evolutionary (“Rapid Application Development”, RAD)

- Performs original functions and is “state of the art” but will continue to evolve in design
- Evolution dependent on internal components and interactions with environment

Embedded Assessment



1) What is a characteristic of all designed products and services?

- A) How a product will work
- B) What are the best materials
- C) How product will be designed
- D) All of the above

2) When designing an object, a person must use:

- A) Creativity
- B) Imagination
- C) Inspiration
- D) All of the above

3) Step 1 of the engineering process is:

- A) Plan & design
- B) Make a model
- C) Make a prototype
- D) Identify & describe the problem

4) A model is:

- A) The final working object
- B) Never changed
- C) Is full scale
- D) None of the above

5) The Engineering Process is the same as the Scientific Process.

- A) True
- B) False

6) Materials used in new models and prototypes do not need to be tested in different environments.

- A) True
- B) False

7) Successful engineers are good in creative and critical thinking that involves math, reading, writing and communication.

- A) True
- B) False

How are these pictures related?

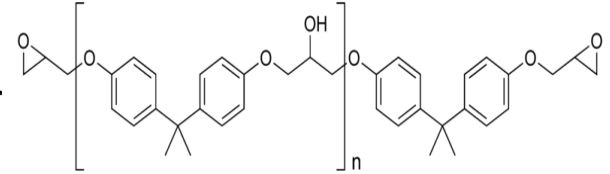


They show either natural tree resin or products made from natural or synthetic resin.

Resin – Organic Polymer

Monomer – single unit

Polymer – usually many units of same type of monomer



Bisphenol A diglycidyl ether; $C_{21}H_{24}O_4$

Polymerization occurs through a series of chemical reactions by which the polymer (a macromolecule) is formed by the linking of monomers

Types : Condensation Polymerization

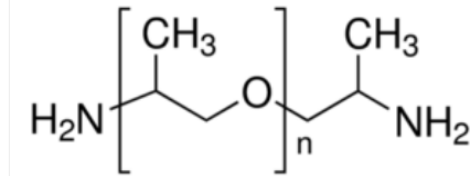
Addition Polymerization

Copolymer – possible two or more monomer species; different monomers with diverse chemical functionalities results in variation of resin properties (*active engineering research area ex. Exxon Mobil*)

Curing Agent

Polypropylene glycol or polypropylene oxide ($C_3H_8O_2$)

- organic polymer of propylene glycol
- often used as curing agent for hardening resin into a solid

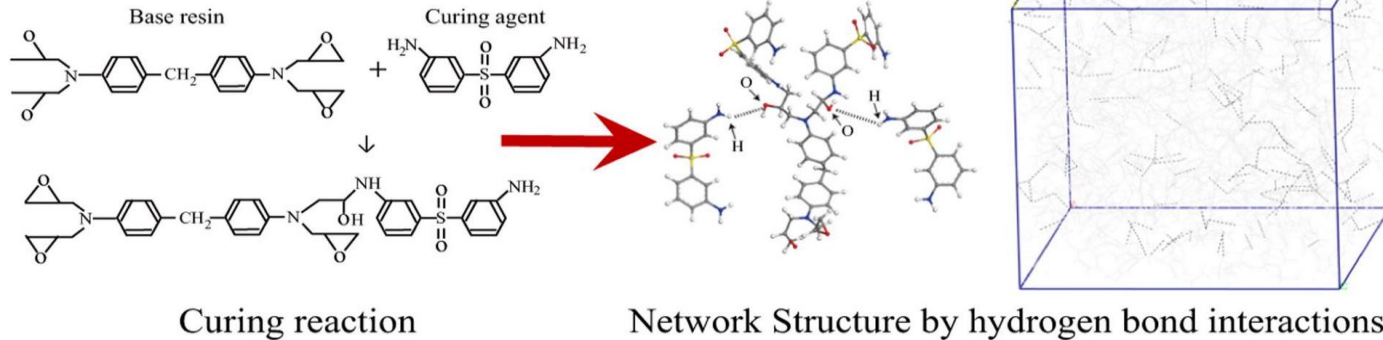


Poly(propylene glycol) bis(2-aminopropyl ether)

Resin Crosslinked by Curing Agent

Crosslink

- covalent or ionic bond that links one polymer chain to another
- cross-links to promote a change in the polymers' physical properties



T Okabe et.al. Molecular dynamics simulation of crosslinked epoxy resins: Curing and mechanical properties. European Polymer Journal 80:78-88 (2016)

Resin – Component in Making Plastics

Resin Polymers - two types depending on reaction to heat



Thermoplastic polymer –

- can repeat softening by heating and hardening by cooling for reshaping and recycling
- original chemical structure as no chemical reaction changes structure

Thermoset polymer –

- prepolymers in a soft solid or viscous state that change irreversibly when heated
- process called **curing** results in covalent crosslinks that change chemical structure



natural resin



Embedded Assessment



Provide the best match the following:

- | | |
|--------------------------|---|
| 1) Thermoset polymer | A) many monomers |
| 2) Copolymer | B) single unit |
| 3) Monomer | C) can be reshaped after cooling and heating |
| 4) Polymer | D) two or more monomers of different species |
| 5) Plant resin | E) used as basis of plastics, adhesives, varnishes & other products |
| 6) Synthetic resin | F) covalent crosslinks during curing changes structure |
| 7) Thermoplastic polymer | G) tree fluid |

Silicone Mold

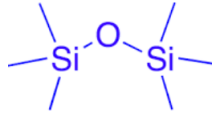
Silicon




- chemical element with the symbol Si
- mineral



Siloxane

- a functional group
- characterized by chain of alternating silicon and oxygen atoms



atomic number	14	28.086	atomic weight
symbol	Si		acid-base properties of higher-valence oxides
electron configuration	[Ne]3s ² 3p ²		crystal structure
name	silicon		physical state at 20 °C (68 °F)

Silicone

- a polymer material made from polymerized siloxanes or polysiloxanes
- consist of an inorganic silicon–oxygen backbone chain (…–SiO–Si–O–Si–O–…)

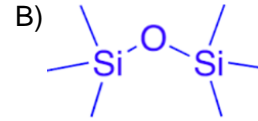


Embedded Assessment



Match the following terms (use terms twice)

- 1) Silicone
- 2) Silicon
- 3) Siloxane

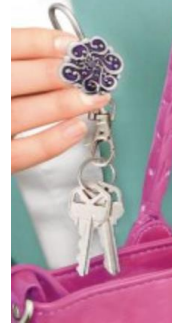


D) functional group

E) material

F) element

Keychain Designed for Function



Design-for-assembly



Design-for-manufacture

Suggested Videos



- **What's an Engineer? Crash Course Kids #12.1**
- <https://www.youtube.com/watch?v=owHF9iLyxic>

- **Prototyping and Model making - Students of Product Design Episode 6**
- <https://www.youtube.com/watch?v=Oee8VfjR1CE>

- **Resin Keychains Tutorial - First Time Making Resin Keychains**
- <https://www.youtube.com/watch?v=Uf6z3SIzn9w>