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Teacher Development Program “Bringing Schools and Engineering Together”

Preliminary Module – Engineered Products
August 2017

Paul Reynolds

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- EA to be your link with the Engineering Profession / Industry
- These forums to provide important networking opportunities with other teaching professionals
- We want to assist in providing exciting ways of presenting concepts with real world examples and applications.
- We encourage a link of support with exam assessors
- We would like to make clear the pathways to engineering that exist for all students- Professional, Trades, VET
- **WE AIM TO BE A FACILITATOR IN SUPPORTING YOU.**

Invention vs Innovation

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INVENTION – is about creating something "new".

INNOVATION – is about the "use" of an idea or method.

INVENTION is easier whilst INNOVATION is more difficult.

Engineered Products – Design Method

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1. Clarification of the need.
Analyse the problem, listing all the restrictions and constraints. This typically follows on from some initial research of a problem and/or identification of design requirements

2. Conceptual design phase.
Generate as many possible solutions to the design problem. From these possible solutions select a number of preferred options that have the greatest chance of achieving the desired objectives.

3. Embodiment/preliminary design phase.
Thorough engineering techniques including modelling and analysis evaluated the preferred options against the design requirements in greater detail.

4. Detailed design phase.
Comprehensive evaluation and optimisation of the preferred design solution through engineering techniques including prototyping and testing.

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Engineered Products – A matter of compromise

Product design is in large part about making compromises and managing expectations as it often deals with a number of competing and conflicting requirements driven by:

- Market
- Price
- Time
- Customer expectations
- International/Australian Standards
- Laws of physics
- Etc…….

Trade off Triangle – Pick Two

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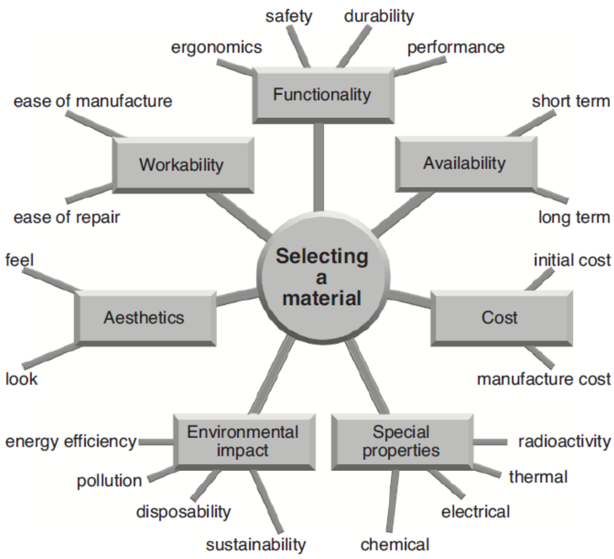
Engineered Products – Material Selection

- The ability of an engineer to select appropriate material for use in a product is **critical**.
- When selecting a material for use in a design, an engineer must consider many things.



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Engineered Products – Material Selection

- To assess a material for selection an engineer will use the **engineering properties of the materials.**
- Requirements of the material may fall into one or more of the following categories:

Mechanical Properties	Physical properties	Chemical properties
• strength	• electrical conductivity	• resistance to corrosion
• elasticity	• thermal conductivity	• stability
• toughness	• relative density	• toxicity
• resistance to creep	• melting point	
• resistance to fatigue	• coefficient of expansion	
• frictional properties	• magnetic properties	
• hardness		

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Engineered Products – Material Selection Charts (Ashby Plots)

- Allow easy visualisation of properties.
- Shows a broad selection of different materials.
- Can be used to ‘drill down’ to specifics.
- A number of charts exists showing a relationships between properties:
  - Young's modulus – Density
  - Strength – Density
  - Strength – Elongation
  - Electrical resistivity – Cost
  - Energy content – Cost
  - Specific stiffness - Specific strength
  - Young's Modulus - Cost
  - Strength - Toughness
  - Strength - Cost
  - Recycle Fraction - Cost
  - Strength - Max service temperature
- Ideal for a first ‘rough cut’ selection.
- Named after creator “Michael Ashby”

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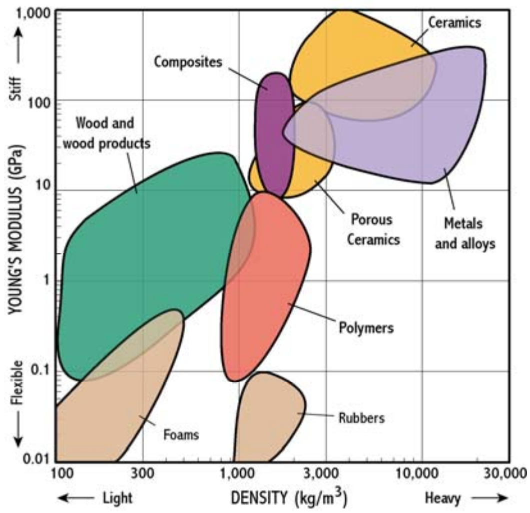
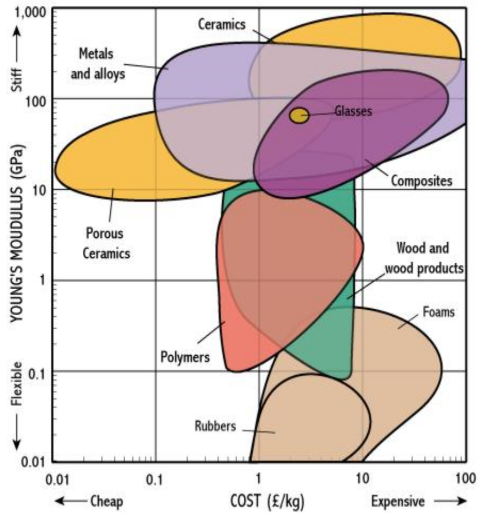
Engineered Products – Material Selection Charts





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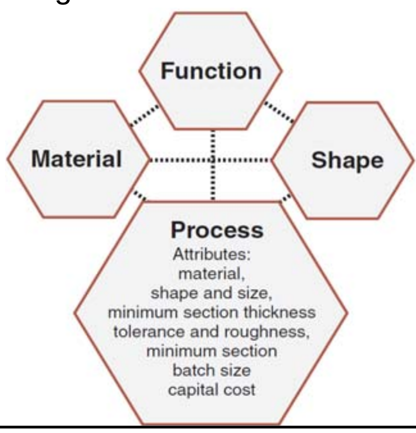
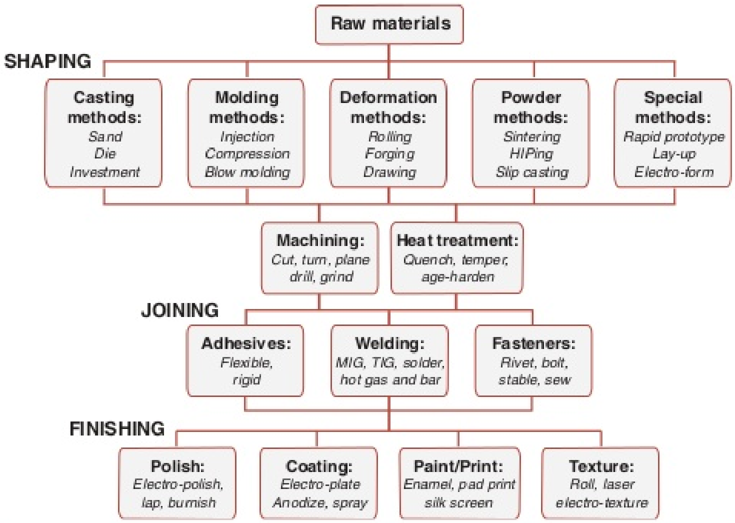
Engineered Products – Process Selection

- A ***"PROCESS"*** is a method of shaping, joining or finishing a material
- ***"PROCESS SELECTION"-*** is finding the best match between process attributes and design requirements.

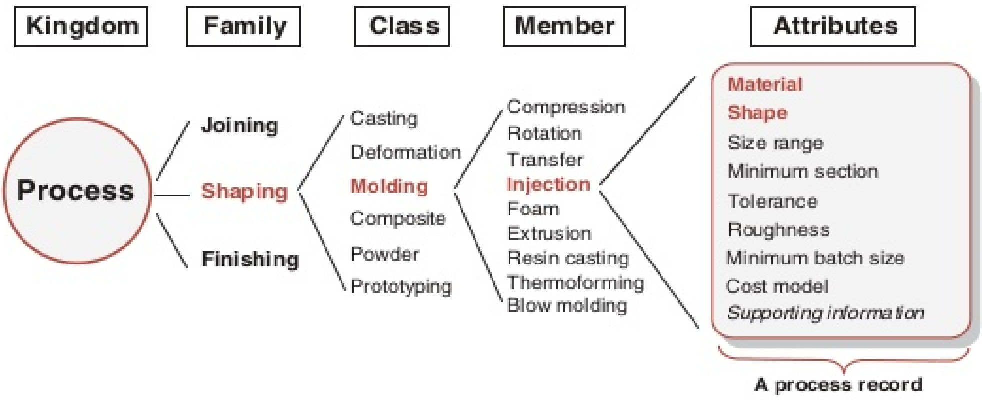
Process selection depends on The function, material and shape. The 'process attributes' are used as criteria for selection.



Engineered Products – Process Selection



Engineered Products – Process Selection



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Engineered Products – Process Selection Charts

Process - Material Matrix: A given process can shape, join or finish some materials and not others. This matrix shows the links between material and process.

		Metals, ferrous	Metals, non-ferrous	Ceramics	Glasses	Elastomers	Thermoplastics	Thermosets	Polymer foams	Composites
Shaping	Sand casting	●	●							
	Die casting	●	●							
	Investment casting	●	●							
	Low pressure casting		●							
	Forging	●	●							
	Extrusion		●							
	Sheet forming	●	●							
	Powder methods	●	●	●						
	Electro-machining	●	●	●						
	Conventional machining	●	●	●	●	●	●	●	●	
	Injection molding				●	●	●	●	●	
	Blow molding				●		●			
	Compression molding				●	●	●	●		
	Rotational molding					●	●	●	●	
	Thermo-forming					●	●	●		
	Polymer casting					●	●	●	●	
	Resin-transfer molding						●	●	●	●
	Filament winding									●
	Lay-up methods									●
	Vacuum bag									●
Joining	Adhesives	●	●	●	●	●	●	●	●	●
	Welding, metals	●	●							
	Welding, polymers					●	●	●	●	
	Fasteners	●	●	●	●	●	●	●	●	●
Finishing	Precision machining	●	●				●	●		●
	Grinding	●	●	●	●					●
	Lapping	●	●	●	●					●
	Polishing	●	●	●	●		●	●		●

The process–material matrix. A red dot indicates that the pair are compatible.

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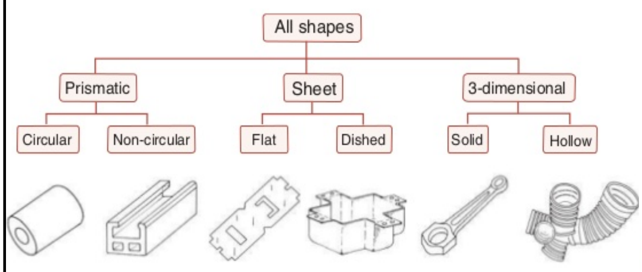
Engineered Products – Process Selection

Process - Shape Matrix: Displays the links between the shape attribute and the process. If the process can not make the shape it may be combined with a secondary process.



Metal shaping; Ceramic shaping; Polymer shaping; Composite shaping

	Circular prismatic	Non-circular prismatic	Flat sheet	Dished sheet	3-D solid	3-D hollow
Sand casting	●	●			●	●
Die casting	●	●			●	●
Investment casting	●	●			●	●
Low pressure casting	●	●			●	●
Forging	●	●			●	
Extrusion	●	●				
Sheet forming	●	●	●	●		
Powder methods	●	●			●	●
Electro-machining	●	●	●		●	●
Conventional machining	●	●	●	●	●	●
Injection molding	●	●			●	●
Blow molding				●		●
Compression molding			●	●	●	
Rotational molding				●		●
Thermo-forming				●		
Polymer casting	●	●			●	●
Resin-transfer molding	●	●	●	●	●	●
Filament winding	●	●		●		●
Lay-up methods			●	●	●	
Vacuum bag			●	●		

The process–shape matrix. Information about material compatibility is included at the extreme left.

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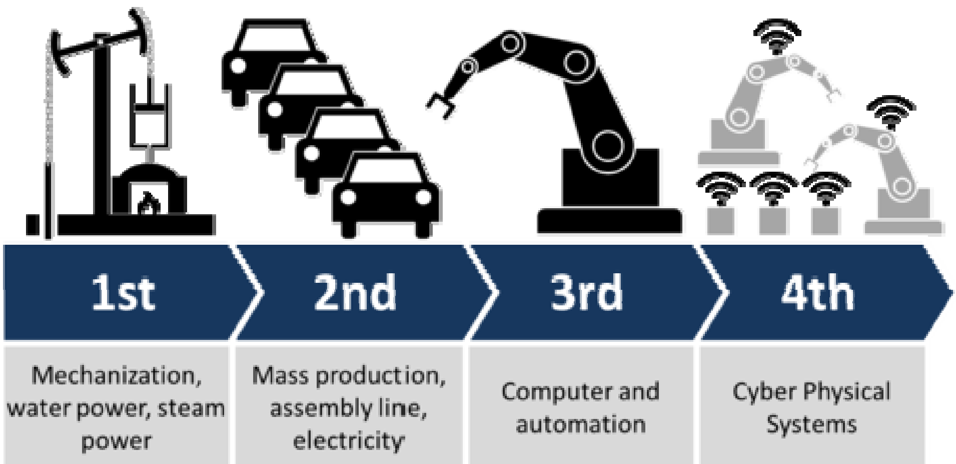
INDUSTRY 4.0 – The 4th Industrial Revolution



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CHANGE IS COMING:

Is it a 'THREAT' an 'OPPORTUNITY' or 'BOTH' ????

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SPEED of CHANGE:

Driven by EMERGING TECHNOLOGIES in the Fields of:

- Artificial Intelligence,
- Robotics
- The Internet of Things (IoT)
- Autonomous vehicles
- Additive Manufacture (3D printing)
- Nanotechnology
- Biotechnology
- Materials science
- Energy storage
- Quantum computing.

FIRST iPhone released: June 2007

FIRST iPad released: April 2010

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COPING WITH CHANGE:

There has not been a more exciting time to be an engineer whose actions will play a critical role in:

- Leading the development of these emerging technologies.
- Implementing smart solutions for both the problems known and unknown.
- A voice to governments and communities on the impacts of these technologies.

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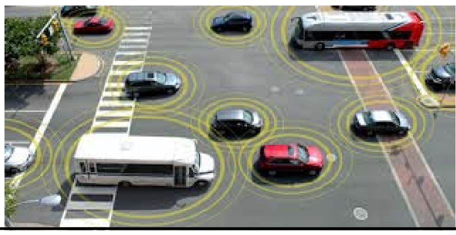
Case Study: The RISE of Transport Network Companies

Transportation Network Companies (TNC) i.e. Uber and Lyft

TECHNOLOGY

- The use of web based applications to change our behavior with how we use and interact with personal and public transport.
- Integration of technologies utilising the Internet of Things (IoT) to provide real time information and data that can be used to improve the experience. i.e. efficient route planning, traffic congestion management etc.
- Enabler for further development of the Autonomous Vehicle



Case Study: The RISE of Transport Network Companies

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SOCIAL

- A flexible way to earn money for the private car owner.
- Major disruption to the Taxi industry.
- Disruption to a cities mass public transport.
- Creation of a sharing economy – will it improve productivity at the expense of safety and wages?
- Peer to Peer services now common place.

Interesting that cities around the world are now making policy and important decisions on Transportation needs that treat a 10 year old company as a fixed variable for decades to come.

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Engineering Studies

Engineered Products:
- Lighting Development

Barry Finlay CPEng FIEAust

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Engineered Products

Technology (push) vs Requirements (pull)

- Technology "push":
    - Technology makes the product possible
    - Hope that a market can be found
    - High-risk approach
- Requirements "pull":
    - Based on proven customer/ user needs
    - Enabling technologies developed in response to meeting those needs
    - More likely to be successful because they already have a market waiting for them

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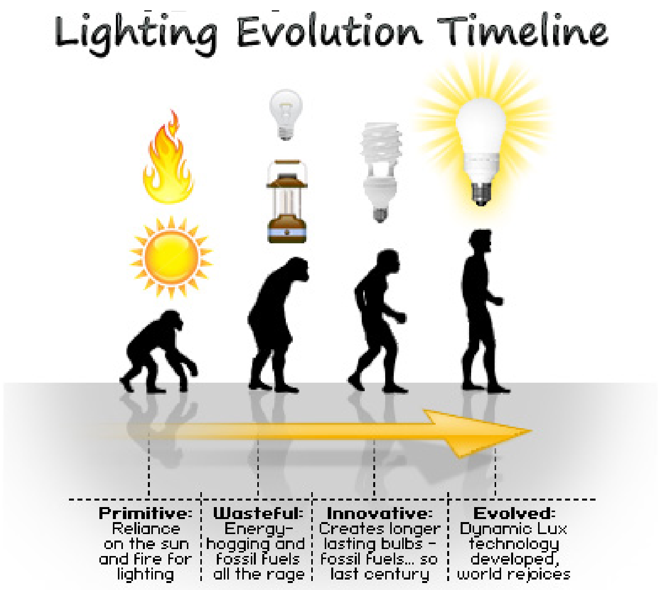
Engineered Products

Technology (push) vs Requirements (pull)

- Over the years product development has been a mixture of the two
    - A user need is identified
    - As technology is developed it is applied to the user need
    - Environmental factors at times impact on speed of development
    - An example of this is lighting
        - Need by humans for lighting after the sun sets
        - Technology available at the time applied to satisfy the need
        - New technology supersedes the old
        - Environmental factors such as greenhouse effect either force search for or accelerate development of new technology



Engineered Products

Artificial lighting:

- Prior to availability of artificial lighting human life dictated by the sun
- Availability of artificial lighting had a major impact on human life
- History of artificial lighting goes back thousands of years:
    - 4500 BCE first oil lamps
    - 3000 BCE candles invented
    - 1792 first gas lamp
    - 1801 – 1803 Humphrey Davey experimented with carbon arcs
    - 1809 Humphrey Davy demonstrated first electric lamp over 10,000 lumens
    - 1815 Humphrey Davy invented the miner's safety lamp

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Engineered Products

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Engineered Products

Artificial lighting:

- History:
  - 1874 Russian Alexander Lodygin patents incandescent light
  - 1880 Edison produced a 16-watt incandescent light bulb
  - 1901 Peter Cooper Hewitt demonstrates mercury vapour lamp
  - 1910 George Claude demonstrates neon lighting at Paris Motor Show
  - 1926 Edmund Germer patents the fluorescent lamp
  - 1962 Nick Holonyak Jr. develops first practical visible spectrum light emitting diode
  - 1981 First Compact Fluorescent Energy Saving Lamps

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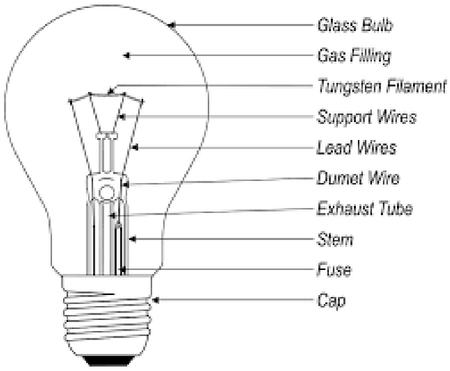
Engineered Products



Incandescent Light Globe

- Attributed to Edison (1879)
- Poor efficiency
- Hot
- Relatively short life
- Available materials at the time

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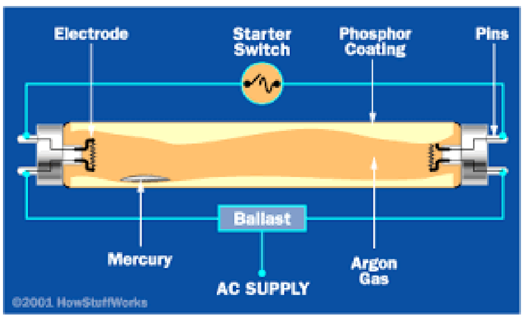
Engineered Products



Fluorescent Lamp

- High efficiency – much more than incandescent
- Long life
- Mercury an environmental concern (hazardous waste)
- Simple materials

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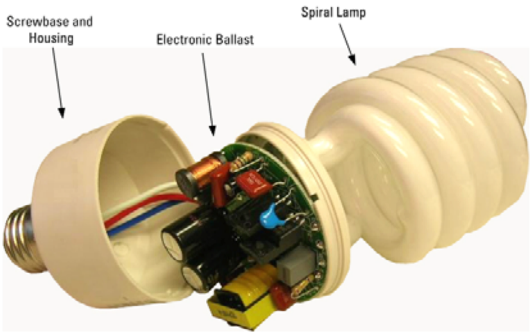
Engineered Products



Compact Fluorescent Lamp

- High efficiency – much more than incandescent
- Long life
- Mercury an environmental concern (hazardous waste)
- Simple materials

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Engineered Products

LED Lamp

- Improving efficiency
- High installation cost
- Low operating cost
- Long life
- Complex materials

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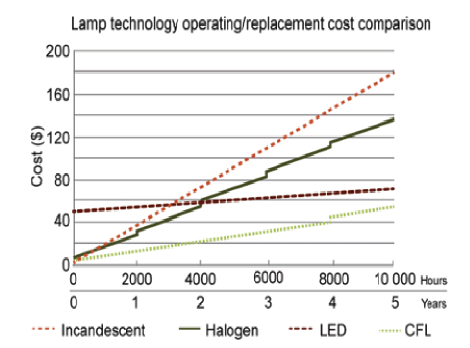
Engineered Products



Bulb Type	Price	Efficacy (lumens/W)	Quantity of Light (lumens)	Light Distribution	Lifetime (hours)	Colour Rendering
LED	> $20	20 - 40	medium	Varies	15 – 50 k	Excellent
CFL	> $ 40	> 40	high	Sphere	5 – 20	Excellent
Linear & circular fluorescent	$5 - 20	> 40	very high	Sphere	> 20 k	Excellent

LED Lamp

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Engineered Products

LED History:

- 1907 Electroluminescence discovered by Marconi Labs
- 1927 First LED by Russian Oleg Losev
- 1955 RCA discovers infrared emission from gallium arsenide
- 1962 Nick Holonyak of GE produced first visible spectrum LED
- 1968 Monsanto first commercial production
- 1972 First blue LED by RCA
- 2000s First high efficiency white light LEDS
- Light output has doubled every 36 months since the 1960s

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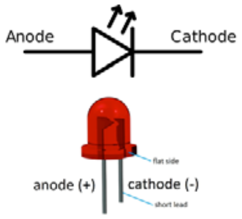
Engineered Products

The LED Lamp



Light Emitting Diode

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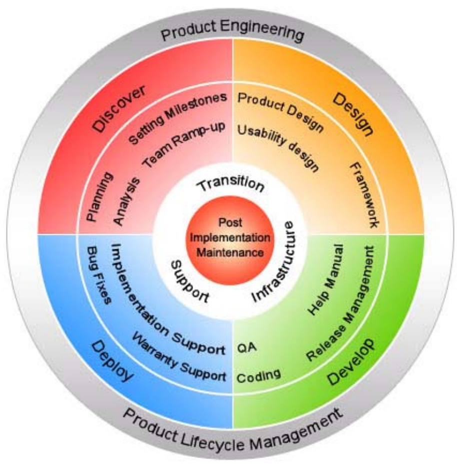
Engineered Products

Engineering the LED lamp:

- Has taken almost a century
- Pure physics and applied physics
- Significant funds
- Engineering:
  - Experiment design
  - Tooling design
  - Manufacture design
  - Manufacture
  - Delivery
  - Customer support/ Maintenance



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Lighting development societal effect:

- Better lighting levels
- Use less energy
- Lower impact on the environment (lower carbon emissions)
- Long life
- Improved safety:
  - Lower temperatures
  - Lower voltages (eventual low voltage house?)
  - Zero UV emission
- Sturdier (use of plastics rather than glass)
- New special applications
- BUT – some hazardous materials – responsible disposal required

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LED Applications

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