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Teacher Development Program
Bringing schools and Engineering together

HSC Course – Personal & Public Transport

http://oraresearch.com/t

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Teacher Development Program
Bringing schools and engineering together

- INTRODUCTION – Personal & Public Transport
- The teacher development program provides current, industry related engineering context to the HSC engineering studies course.
- This module is part of a series of 8 modules providing relevant material to the course learning outcomes.
- The presentations provide a forum for teaches to network and interact with Engineers Australia.
- WE AIM TO BE A FACILITATOR IN SUPPORTING YOU.

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Engineering Studies syllabus structure

Preliminary modules *120 hours indicative time	HSC modules *120 hours indicative time
Engineering application module 1 Engineering fundamentals	**Engineering application module** Civil structures
Engineering application module 2 Engineered products	**Engineering application module** Personal and public transport
Engineering application module 3 Braking systems	**Engineering focus module** Aeronautical engineering
Engineering focus module 4 Biomedical engineering	**Engineering focus module** Telecommunications engineering

This Module

The Syllabus-HSC Modules

Student Learnings

Engineering application module: Personal and public transport

30 hours indicative time

Select one or more forms of transport in this module. Some examples include: bicycles, motor cars, boats, motor cycles, buses, trucks, trains and trams.

Outcomes

A student:

- H1.2 differentiates between the properties and structure of materials and justifies the selection of materials in engineering applications
- H2.1 determines suitable properties, uses and applications of materials, components and processes in engineering
- H3.1 demonstrates proficiency in the use of mathematical, scientific and graphical methods to analyse and solve problems of engineering practice
- H3.2 uses appropriate written, oral and presentation skills in the preparation of detailed engineering reports
- H3.3 develops and uses specialised techniques in the application of graphics as a communication tool
- H4.1 investigates the extent of technological change in engineering
- H4.2 applies knowledge of history and technological change to engineering-based problems
- H4.3 applies understanding of social, environmental and cultural implications of technological change in engineering to the analysis of specific engineering problems
- H5.1 works individually and in teams to solve specific engineering problems and prepare engineering reports
- H6.1 demonstrates skills in research and problem-solving related to engineering
- H6.2 demonstrates skills in analysis, synthesis and experimentation related to engineering.

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Personal Transport

- *H4.1 investigates the extent of technological change in engineering*

Public Transport

- *H4.1 investigates the extent of technological change in engineering*

Comparison

- *H4.1 investigates the extent of technological change in engineering*

PERSONAL TRANASPORT		PUBLIC TRANSPORT	
ADVANTAGES	**DISADVANTAGES**	**ADVANTAGES**	**DISADVANTAGES**
Available on demand	Owner responsible for running costs	No parking or garaging issues	Little control over the timetable or route
Greater Convenience	Most vehicles require special training and licensing	No special training or licensing	Comfort and personal security not as high compared to personal transport
Personnel choice	Strict laws apply to the use of most vehicles	Can be used by a greater % of population	High initial costs to communities to establish and tax payer costs to maintain.
Greater levels of comfort	Greater chance of accident	Less chance of accident	Not available in all areas
Greater levels of security	Greater impact on air pollution and traffic congestion	Pay only when you use	

Bicycle Evolution

- *H4.1 investigates the extent of technological change in engineering*

1864 – Velocipede or *"Boneshaker"*

- Direct drive pedal crank
- Wrought iron frame
- Timber wheels with metal rims
- Weight = 27kg
- Top Speed = 13 km/hr

2010 – Peugeot BK1 Concept Bike

- Chainless drive
- Carbon fibre frame <1kg
- Top Speed >133 km/hr

Light Rail Evolution

- *H4.1 investigates the extent of technological change in engineering*

1890's – STEAM TRAM in Hunter Street, Newcastle.

1940's – ELECTRIC TRAM (overhead) in Hunter Street, Newcastle.

2019 – ELECTRIC TRAM (Battery) in Hunter Street, Newcastle.


One that with change fundamentally how we:
LIVE
WORK
RELATE TO ONE ANOTHER
“WE STAND ON THE BRINK OF A TECHNOLOGICAL REVOLUTION”

INDUSTRY 4.0 – The 4th Industrial Revolution

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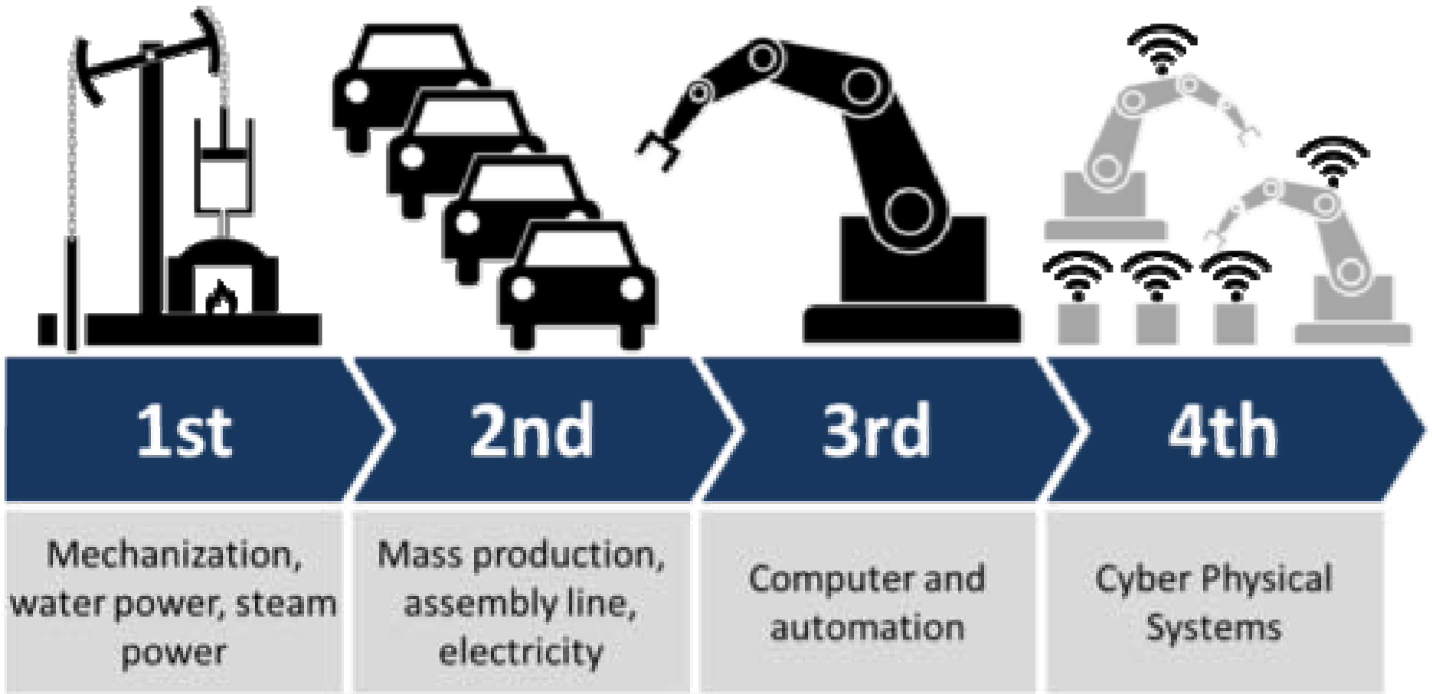

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CHANGE IS COMING:

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

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

COPING WITH CHANGE:

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

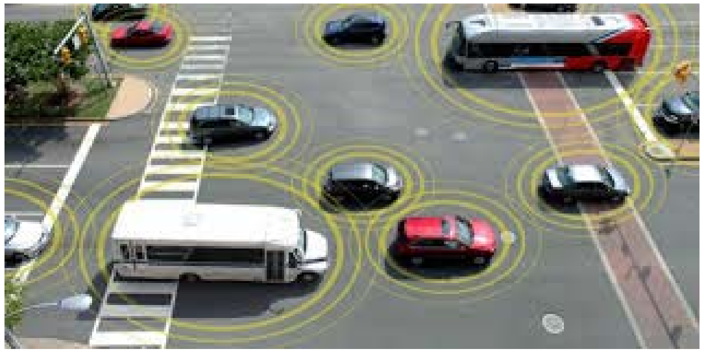
- Leading the development of these emerging technologies.
- Implementing smart solutions for both the problems known and unknown.
- A voice to governments and communities on the impacts of these technologies.

Case Study: The RISE of Transport Network Companies

- *H4.3 applies understanding of social, environmental and cultural implications of technological change in engineering to the analysis of specific engineering problems*

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

SOCIAL IMPLICATIONS

- 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.

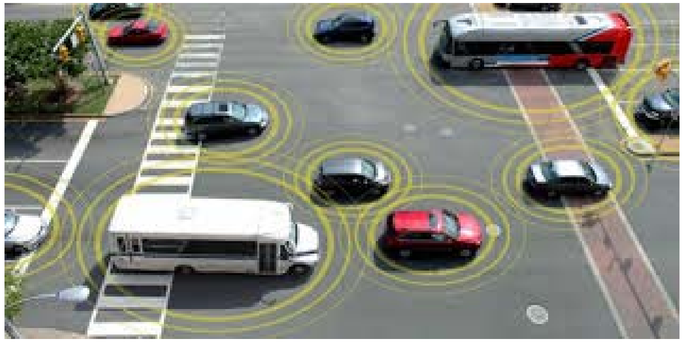
Case Study: The Autonomous Car

- *H4.2 applies knowledge of history and technological change to engineering-based problems*
- *H4.3 applies understanding of social, environmental and cultural implications of technological change in engineering to the analysis of specific engineering problems*

An autonomous car is a vehicle that is capable of sensing its environment and navigating without human input.

DRIVERS:

- Technology available
- Environmental benefits
- Road safety benefits

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Case Study: The Autonomous Car

Catalyst for the realisation of the autonomous car:

- Improvements in battery technology and economics
- Improvements in electric motor technology

→ **Arrival of the electric car**

- Fast compact computing
- Low cost transducers including digital cameras and video, radar, Lidar and GPS

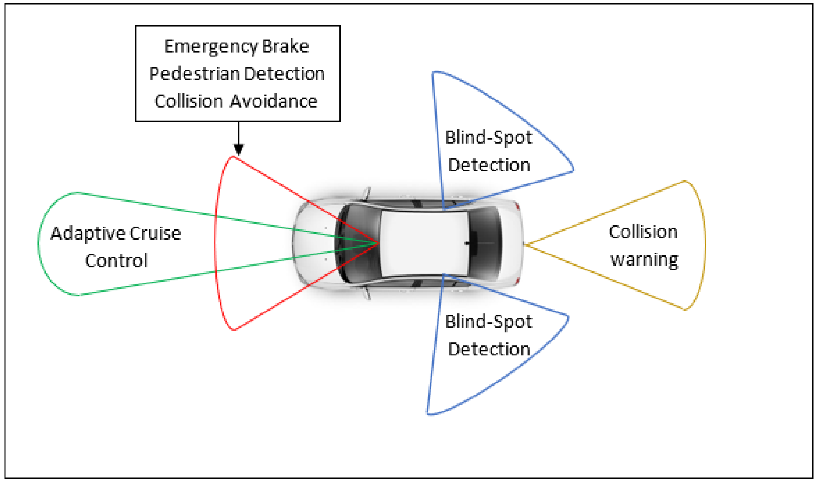
→ **Arrival of Advance Driver Assistance System (ADAS)**

Case Study: The Autonomous Car

The Technology

Radar:

- Has been in cars for many years
- Underpins familiar tech like adaptive cruise control and automatic emergency braking
- Reliable and impervious to foul weather, it can see hundreds of yards and can pick out the speed of all the objects it perceives
- It's nowhere near precise enough to tell the computer that you're a cyclist, but it should be able to detect the fact that you're moving, along with your speed and direction,

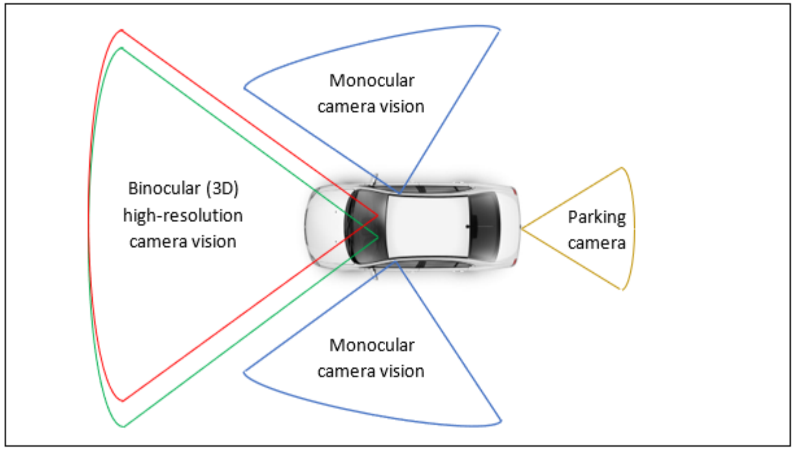


Case Study: The Autonomous Car

The Technology

Cameras:

- Let autonomous cars see lane lines and road signs
- They only see what the sun or your headlights illuminate, though, and they have the same trouble in bad weather that you do
- Elon Musk thinks cameras alone can enable a full autonomous takeover
- Most engineers don't want to depend on just cameras
- Some emergency braking technology relies on cameras



Case Study: The Autonomous Car

The Technology

Lidar:

- Light Detection and Ranging
- Provides high-resolution, three-dimensional information about the surrounding environment
- LiDAR can simultaneously locate the position of people and objects around the vehicle and assess the speed and route at which they are moving. Using that information, an on-board computer system can determine the safest way for a self-driving vehicle to drive to its destination.

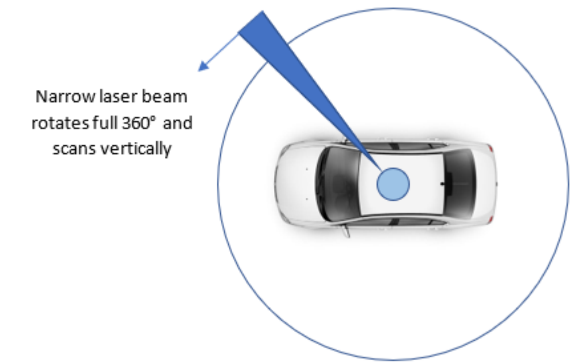


Figure 2. Scanning Lidar

Case Study: The Autonomous Car

The Technology

GPS:
- Global positioning system
- Geographic location of car
- Guidance on a macro scale
- Accuracy of around 5 meters

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Case Study: The Autonomous Car

The Technology

Inertial Measurement Unit (IMU):

- Electronic device that measures and reports a body's specific force, angular rate, and sometimes the magnetic field surroundings the body, using a combination of accelerometers and gyroscopes, sometimes also magnetometers.
- Key dynamic sensor to to steer the vehicle dynamically
- Maintain a better than 30 cm accuracy level for short periods (up to 10 seconds) when other sensors go off line
- Also used in algorithms that can cross compare multiple ways to determine position/location and then assign a certainty to the overall localization estimate

Case Study: The Autonomous Car

The Technology

IoT:

- Internet of Things
- Autonomous car also needs to communicate with infrastructure surrounding it through the internet
- Traffic signals, traffic control and other cars, for example, will communicate with the car
- Will be supported by 5G telecommunications technology

Case Study: The Autonomous Car

Classification of autonomous cars

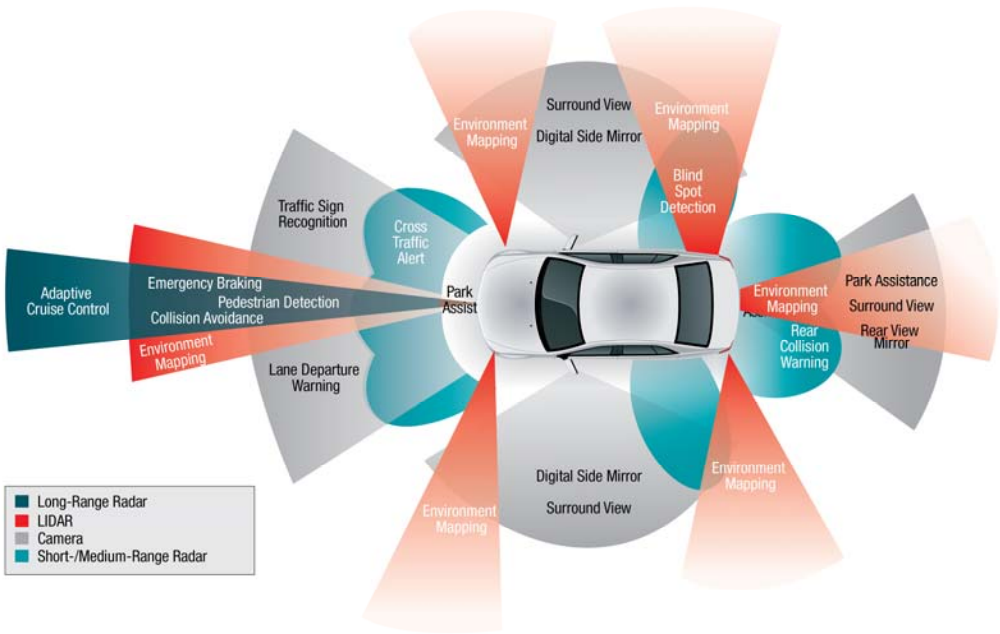
Five levels of automation:

1. Driver assistance: driver assistance systems support the driver, but do not take control
2. Partly automated driving: systems can also take control, but the driver remains responsible for operating the vehicle
3. Highly automated driving: in certain situations, the driver can disengage from driving for extended periods of time
4. Fully automated driving: the vehicle drives independently most of the time. The driver must remain able to drive, but can, for example, take a nap.
5. Full automation: the vehicle assumes all driving functions, the people in the vehicle are only passengers

Case Study: The Autonomous Car

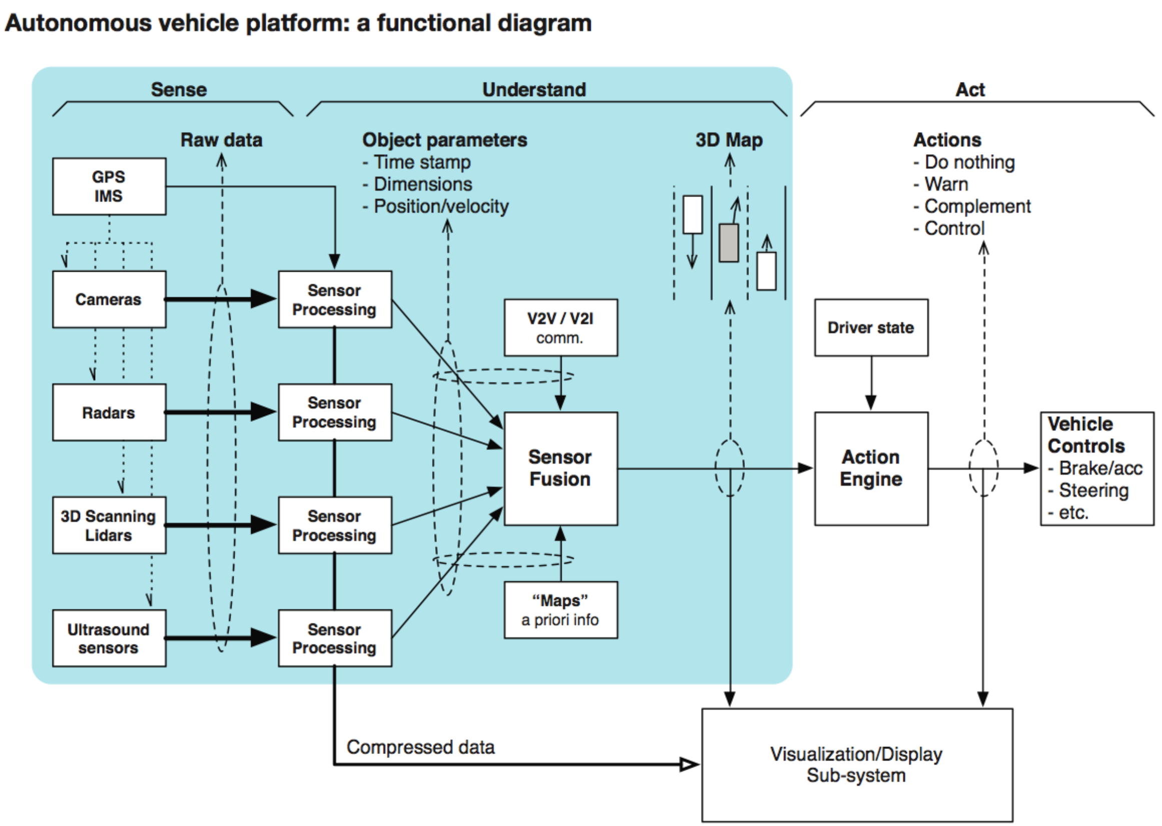
The System

Information from all sensors and transducers must be processed in real time



Case Study: The Autonomous Car

The System



Case Study: The Autonomous Car

Environmental Impact

The autonomous vehicle will have major environmental advantages:

- Lower fuel consumption and emissions:
- Electric drive
- Lower weight
- Optimal driving compared to human (less unneeded acceleration and braking)
- Fewer cars needed as cars can do multiple jobs (not sitting in a car park all day)
- Shortest route taken
- Less congestion ?
- Less likely to have an accident and contaminate the area

Case Study: The Autonomous Car

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Social Impact

The autonomous vehicle will result in major social changes:

- Fewer cars needed per household - eventually no need to own a car
- Car garages in houses a thing of the past?
- Fewer deaths and injuries as driverless cars are safer than human-driven cars
- Who is liable for damage and what is the legal framework
- Resistance for individuals to give up control
- Security concerns with hacking
- Loss of privacy
- Drivers being inexperienced if situations arose requiring manual driving
- Humans banned from driving cars eventually
- Ethical problems with software being forced to chose a harmful course of action in the event of an unavoidable crash.
- Employment – loss of a number of occupations but creation of others.

Case Study: The Autonomous Car

When?

- Many cars on the road today are set up for autonomous driving but still operating at level 2
- Within the next couple of years we will see full autonomous cars operating at level 5

NEWCASTLE HERALD
NOVEMBER 9 2018 - 10:17AM

Newcastle council launches driverless bus trial around city's harbour, beaches

Exam Questions - 2018

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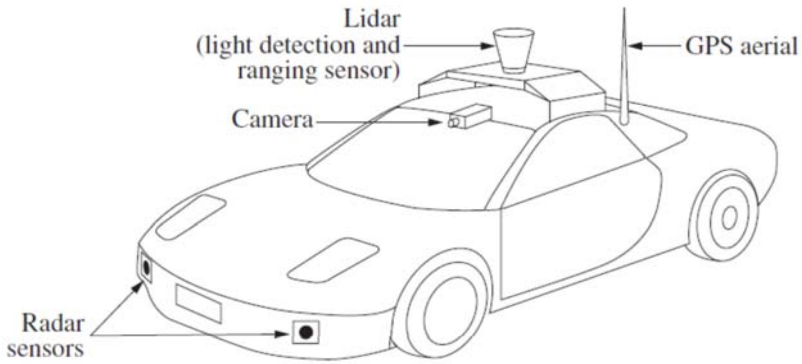
Question 21 (12 marks)

The diagram shows a self-driving electric vehicle.



(a) Innovations in global positioning systems (GPS) and sensor technologies are used in the operation of this vehicle.

Describe how both of these innovations are used in the control of the vehicle.

Answer:

GPS use triangulation to determine the vehicle's position on the surface of the earth.
Sensors are used to detect objects in the vehicle's path or its immediate environment in order to avoid collision.

Exam Questions - 2018

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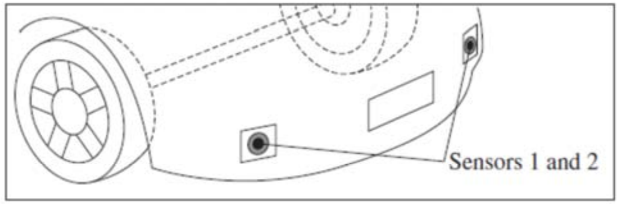
Question 21 (continued)

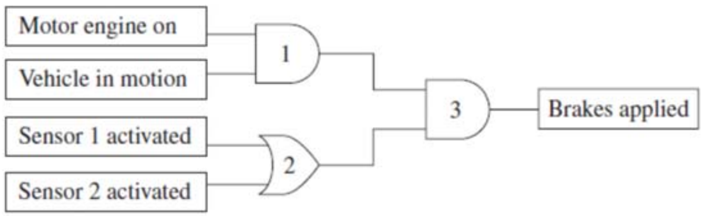
(d) Digital logic controls the vehicle's brakes.



Brakes will be applied when all of the following conditions are met:

- the motor is on
- the vehicle is in motion
- either sensor 1 or sensor 2 is activated.

Explain how the logic gates, labelled 1, 2 and 3 in the circuit below, control the vehicle's brakes.



Answer:

1. AND gate 1 – both inputs ON to produce ON output
2. OR gate – either input ON to produce ON output
3. AND gate 2 – both inputs ON to produce ON output (therefore brakes applied).

Case Study – Dynamic Seat Testing

H3.1 demonstrates proficiency in the use of mathematical, scientific and graphical methods to analyse and solve problems of engineering practice

- Design of the OSC walkover seat involved the use of FEA (Finite Element Analysis) computer simulation software, however this needed to be validated by physical testing.
- The seat was designed to withstand a number of static and dynamic loads including amongst others.
  - 5g longitudinal deceleration force
  - 2g lateral deceleration force
  - 2g vertical deceleration force
  - Impact load of a 95th percentile male striking the seat at 4.5m/s

Case Study – Dynamic Seat Testing

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Whilst a number of formal test houses exist that offer the service of dynamic testing.


Their limitations included being expensive at $15K per test and having their facilities located overseas.

Case Study – Dynamic Seat Testing

PROBLEM STATEMENT

" How then to reliably and economically test the performance of a passenger rail OSC walkover seat to withstand a number of varying 'g' force decelerations".

Case Study – Dynamic Seat Testing

ANSWER – Assign to an engineer !

The test apparatus needed to be:

- Repeatable
- Inexpensive
- Minimal setup time
- Ability to test the varying load conditions

This involved a number of unique challenges the first of which was how to provide the propulsion of the seat for the deceleration test - and the answer came not in the use of a motor for propulsion but in using gravity.

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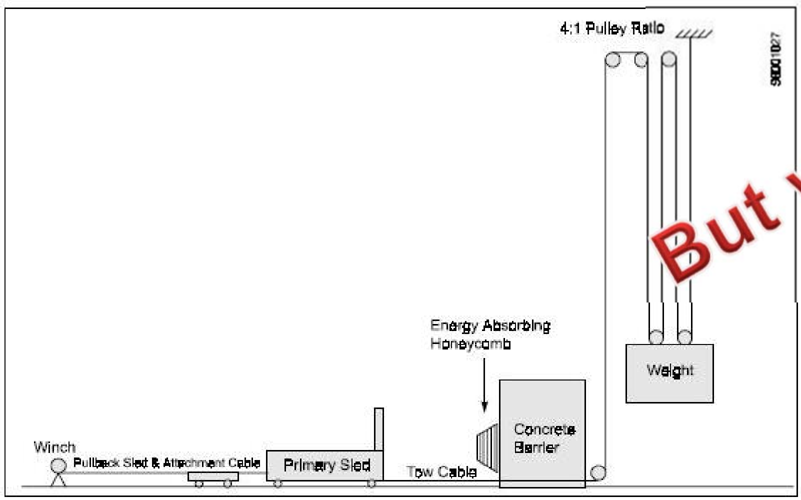
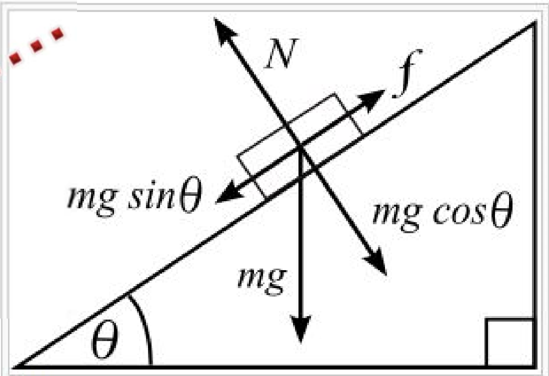
Case Study – Dynamic Seat Testing

- Existing gravity driven test method



But why not....

- Use the mass of the seat itself i.e. INCLINED PLANE



Key:
N = Normal force that is perpendicular to the plane
m = Mass of object
g = Acceleration due to gravity
θ (theta) = Angle of elevation of the plane, measured from the horizontal
f = frictional force of the inclined plane

Case Study – Dynamic Seat Testing

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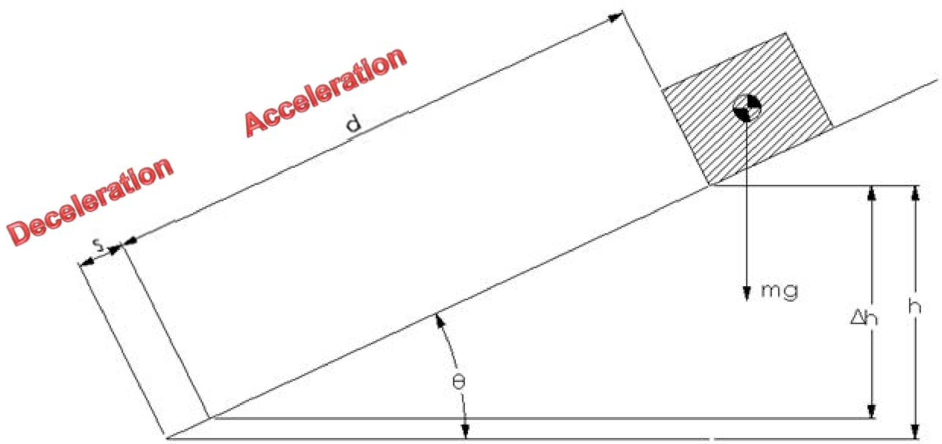
INPUTS

s =	Stopping Distance	0.25	m
d =	Distance of Travel	2.86	m
m =	Total Mass	421.5	kg
μ =	Coefficient of Friction	0.05	
	Deceleration (g's)	5	
	Actual Stopping dist	0.246	

OUTPUTS ○ No Friction ◉ Friction

h_t =	Total Height	1.50	m
Δh =	Change In Height	1.38	m
θ =	Angle of Inclined Plane	28.74	Degrees
V =	Velocity at Impact	4.95	m/s
E =	Energy at Impact	5168.64	J
	Actual Deceleration	5.08	g



Calculations:

VELOCITIES DURING BUFFER STOP (s)

$$V_1^2 = V_0^2 + 2as$$

Vo	= Initail Velocity	4.95	m/s
Vi	= Final Velocity	0	m/s
s	= Stopping Distance	0.25	m
a	= Deceleration (5g)	-49.05	m/s^2

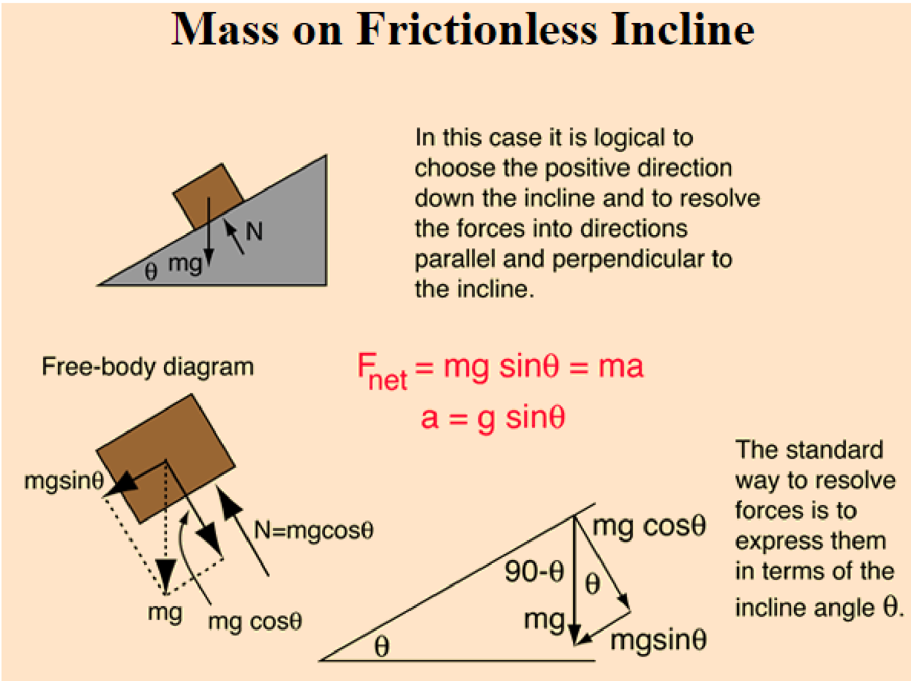
VELOCITIES DURING INCLINED PLANE (d)

Without Friction

$$V_1^2 = V_0^2 + 2as$$

Vo	= Initial Velocity	0	m/s
Vi	= Final Velocity	4.95	m/s
s	= Distance Travelled	2.86	m
a	= Acceleration	4.29	m/s^2

Case Study – Dynamic Seat Testing



Calculations:

F = ma
F = mgsinθ
a = gsinθ
θ = Sin-1(a/g)
h = (d+s)sinθ

m	= Total Mass	421.5	kg
g	= Gravity	9.81	m/s^2
a	= Acceleration	4.29	m/s^2
F	= Force Parallel to Incl.	1807.22	N
θ	= Angle of Incline	25.92	Degrees
h	= Total Height of Mass	1.36	m
Δh	= Change Height of Mass	1.25	m

Case Study – Dynamic Seat Testing

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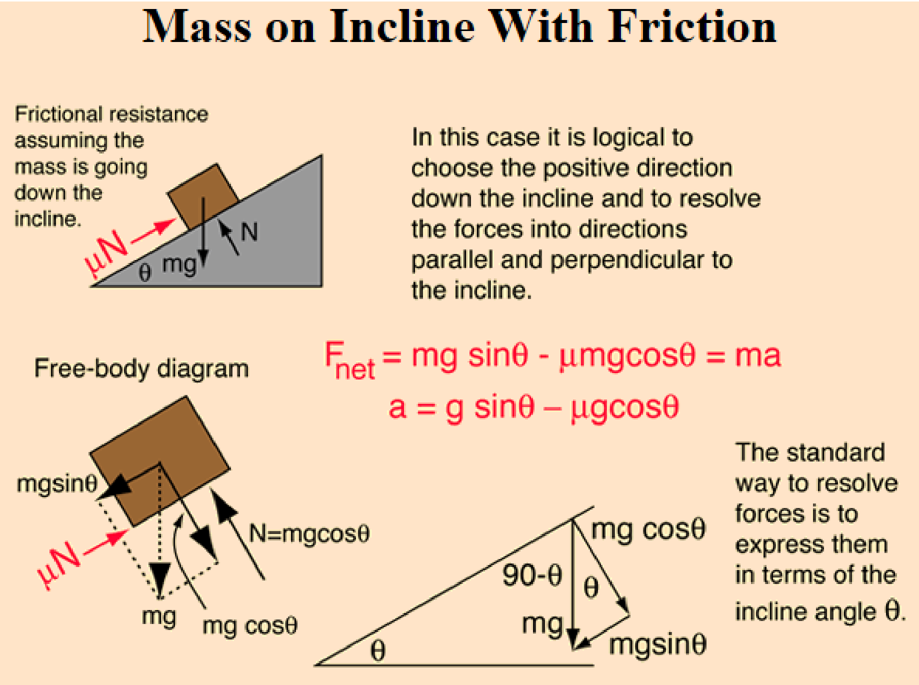


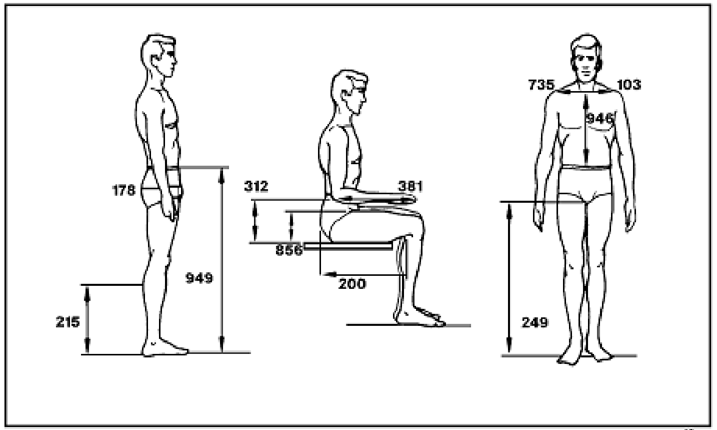
Calculations:

F = ma
F = mgsinθ - umgcosθ
a = gsinθ - ugcosθ
θ = to be solved using Tangent half angle substitution
h = (d+s)sinθ

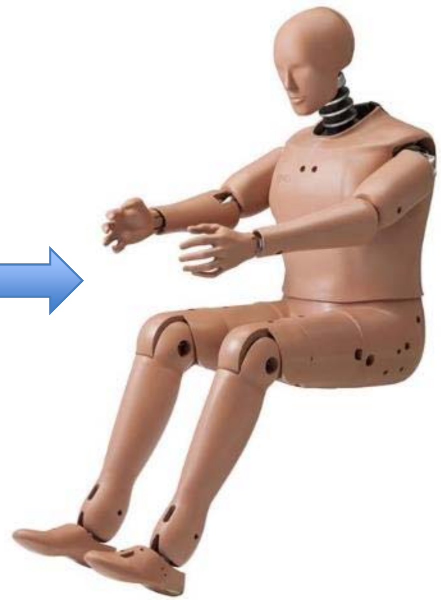
m	= Total Mass	421.5	kg
g	= Gravity	9.81	m/s^2
a	= Acceleration	4.29	m/s^2
F	= Force Parallel to Incl.	1988.49	N
θ	= Angle of Incline	28.74	Degrees
h	= Total Height of Mass	1.50	m
h	= Total Height of Mass	1.38	m
μ	= Coefficient of Friction	0.05	

Case Study – Dynamic Seat Testing

The 95th percentile male:



Body Mass = 94kg



Case Study – Dynamic Seat Testing

Case Study – Dynamic Seat Testing

Case Study – Dynamic Seat Testing

Things don't always go to plan…..

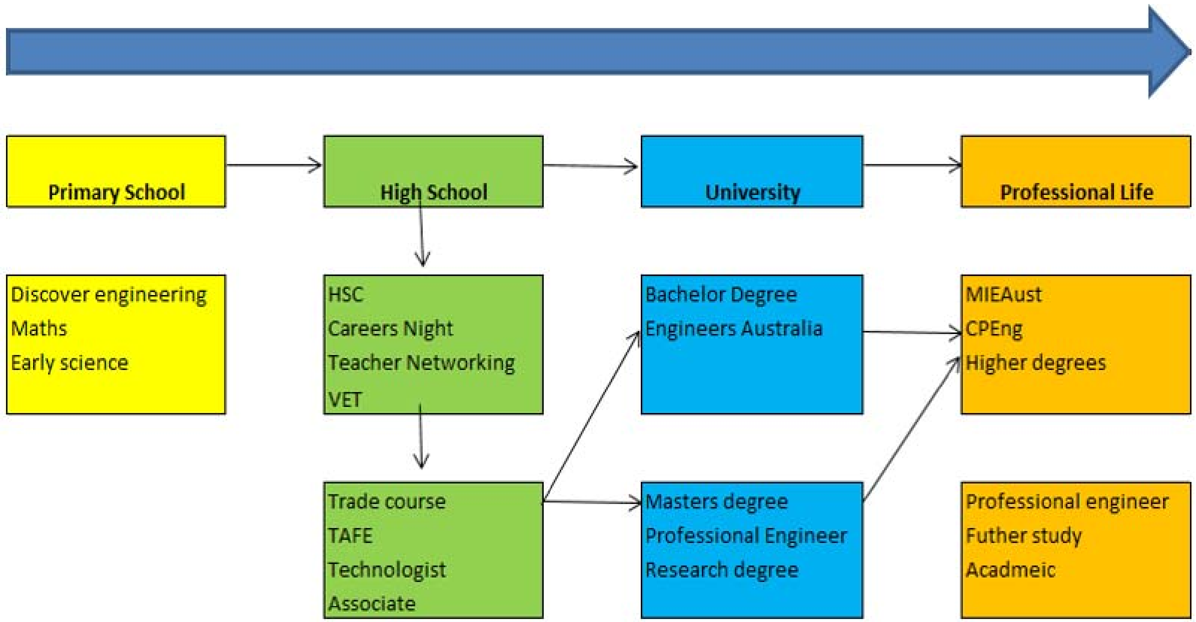
What went wrong:

- Pressure on the brake pads too high resulting in >25g-force
- Not the best place for a hard edged steel frame to be positioned at the end of the incline.

Summary

- Engineers Australia is your link with the Engineering Profession / Industry
- These Presentations and forums can provide important networking opportunities with other teaching professionals
- Engineers Australia can assist in providing exciting ways of presenting concepts with real world examples and applications.
- We encourage a link of support with exam assessors
- We emphasise that pathways to engineering exist for all students- Professional, Technical, Trade, VET

Pathways to Engineering



Engineers Australia is the trusted voice of the profession. We are the global home for engineering professionals renowned as leaders in shaping a sustainable world.

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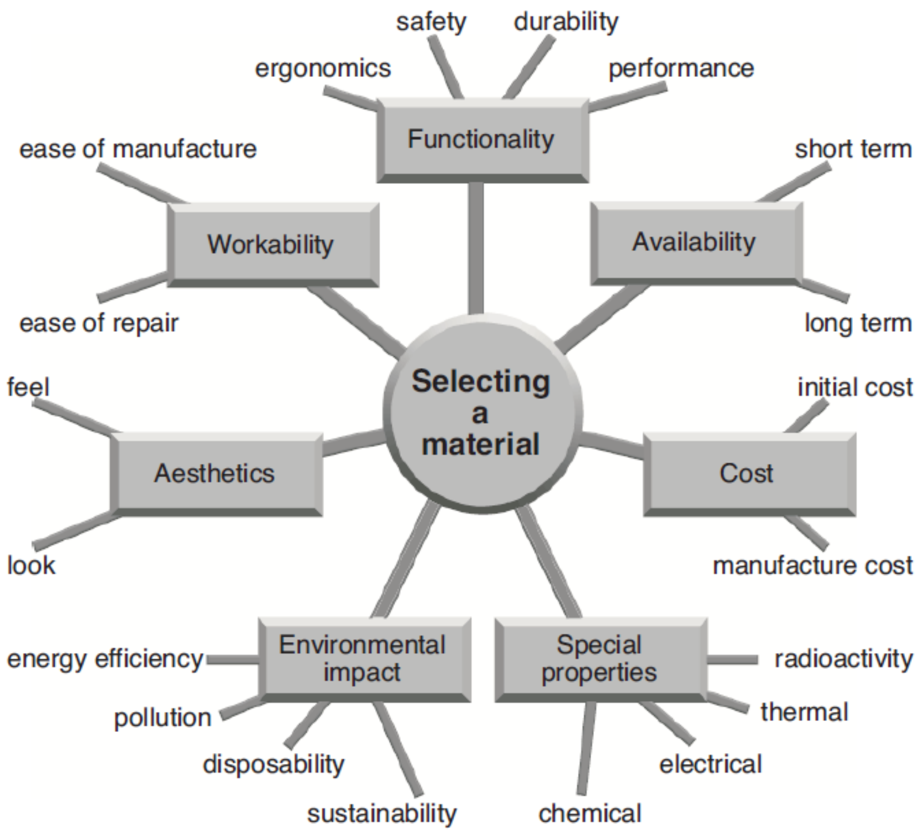
Engineered Products – Material Selection

- 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.



Engineered Products – Material Selection

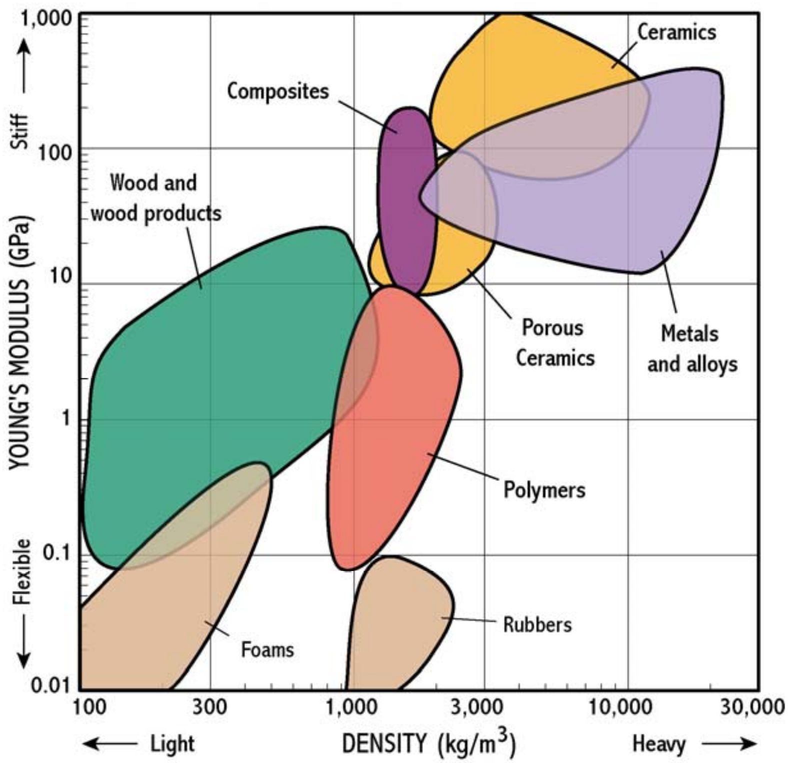
- To assess a material for selection an engineer will use the **engineering properties of the materials.**
- Requirements of the material may fall into one or more of the following categories:

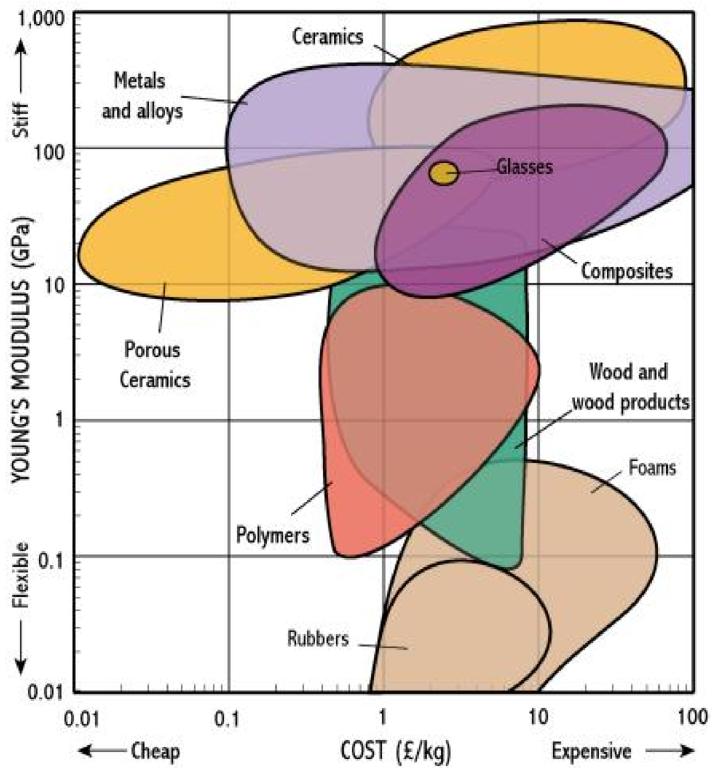
Mechanical Properties	Physical properties	Chemical properties
• strength • elasticity • toughness • resistance to creep • resistance to fatigue • frictional properties • hardness	• electrical conductivity • thermal conductivity • relative density • melting point • coefficient of expansion • magnetic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

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”

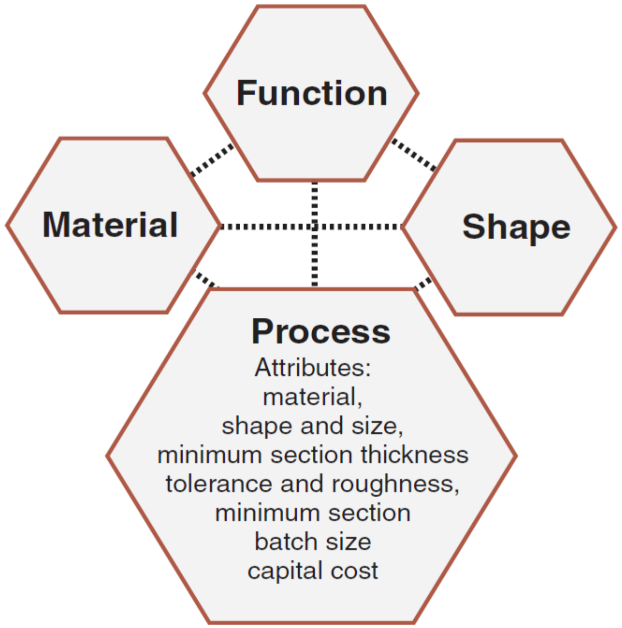
Engineered Products –
Material Selection Charts





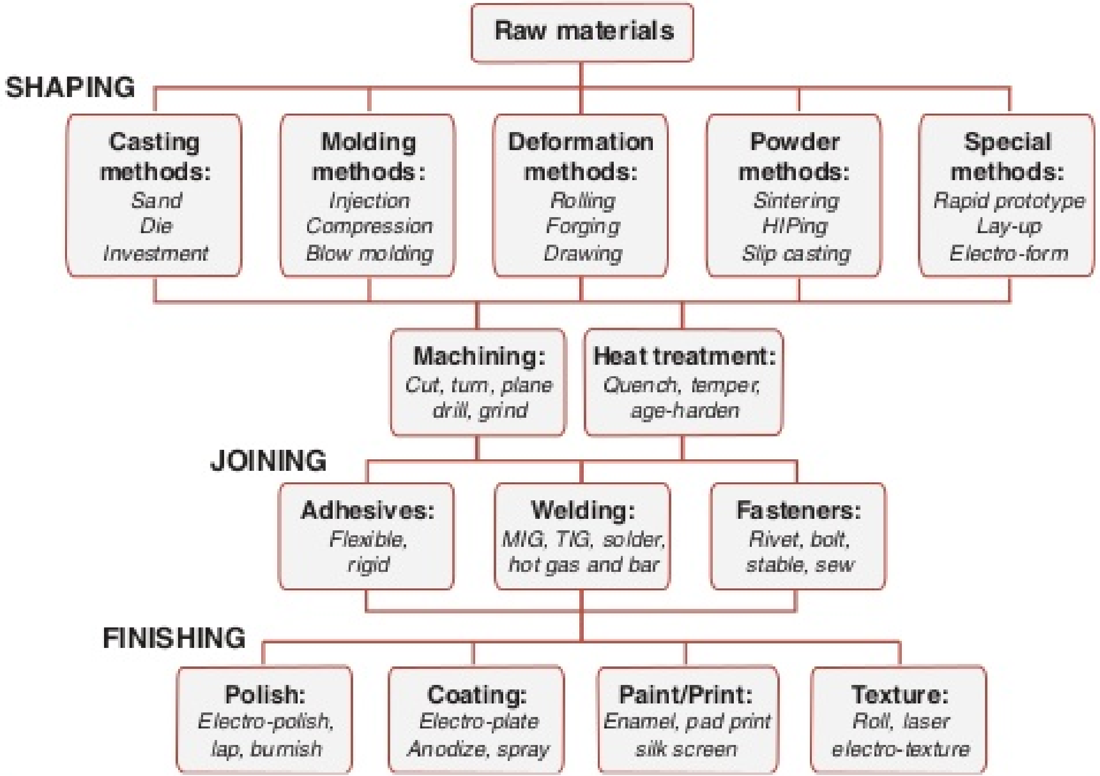
Engineered Products –
Process Selection

- 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.

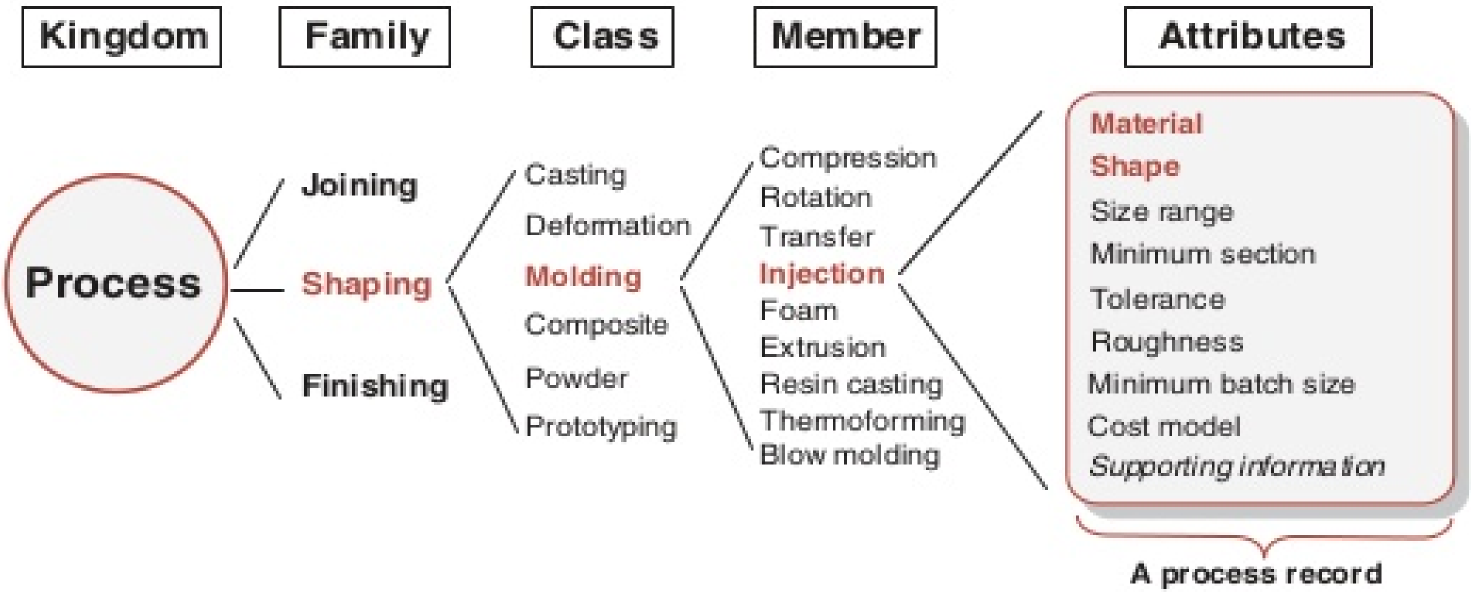


Process selection depends on The function, material and shape. The 'process attributes' are used as criteria for selection.

Engineered Products – Process Selection



Engineered Products – Process Selection



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Engineered Products – Process Selection Charts

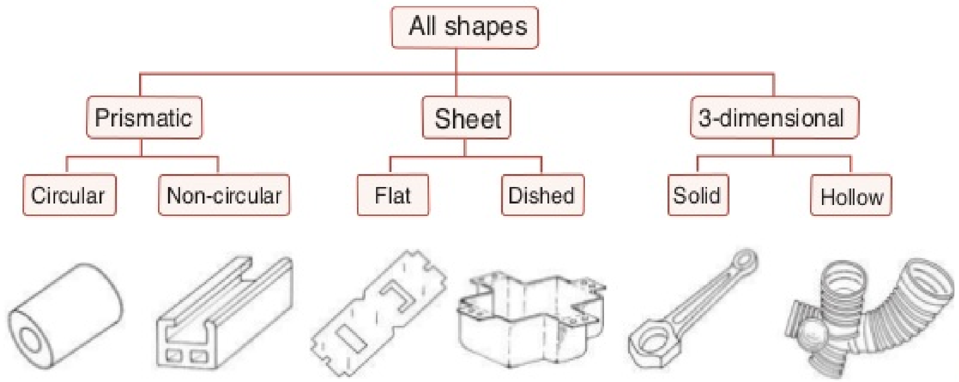
Process - Material Matrix: A given process can shape, join or finish some materials and not others. This matrix shows the links between material and process.

	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.

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.