MIGHTY MATERIALS

Mighty Materials

A traveling exhibition on material science engineering

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Executive Summary

"Mighty Materials" is an exhilarating, interactive and problem-solving ride into the world of material science engineering. Visitors will experience a range of exhibits from full-body immersive exhibits to open-ended puzzles as they are guided through this diverse and topical field.

In the past, materials have been selected from nature for particular uses based upon the properties of that material. Over time we have changed the world to suit our needs, engineering materials to possess desired properties, rather than trying to find a natural material to fulfill our requirements. This has been so important for human development that we have even named our historical periods after the most advanced materials that were used at the time. Nowadays, we can appreciate the amazing science behind material engineering by examining the properties and functions of everyday objects.

Based on this context, this exhibition is designed to communicate three key messages:

1. Materials have specific properties that allow them to be used and engineered further to fulfil certain functions.
2. Almost everything we use in our everyday lives has been engineered to suit a purpose.
3. Australian scientists, including CSIRO scientists, are at the forefront of material science engineering in the global arena.

The exhibits are built in a variety of styles to convey these key messages. Visitors will marvel at the end products of engineering, from ancient materials (for example, the exhibit 'Digging Deep') to modern and futuristic technologies ('Titanic Tension', 'Printing with Plastic', and 'Blade Running'). Visitors will also come to understand some of the different properties that certain everyday materials display (conductivity in 'Power Push', density in 'Dabbling with Density') and why they might display those properties (atomic structure in 'Structurally Sound'). Visitors will be surprised to learn about the depth of contribution that Australian scientists have made to material science engineering ('Aussie Innovation'). Finally, visitors will have the chance to go through the engineering process themselves ('Bridging the Gap', 'Processing Power').

Visitors will be able to link exhibit concepts to their everyday world through exhibits showing the engineered properties of the clothes we wear, or by viewing the video exhibit 'Material Messages' that displays glass blowers and jewelers as the materials engineers that they are. Visitors may also be introduced to new concepts and will be able to observe a 3D printer in action or experience first-hand the properties of prosthetics worn by medalwinning Paralympic athletes. The overlap of content between exhibits ensures that visitors receive clear messages in a fun, interactive and enjoyable setting.

Material science engineering is an especially important topic for Australia, in the current world economic climate. We are in the middle of a resources boom, but increasingly our natural resources are being sold or moved offshore. A large part of Australia's future prosperity is contingent upon developing our onshore manufacturing industry to compete with other innovative nations. To do this, Australia will need bright, inspired, enthusiastic material science engineers. Research organisations such as CSIRO are already making great strides in the international material science engineering field, and exhibitions like this one will build upon and promote the great work which is already being done in Australia. The 'Inspiring Australia' initiative is a key strategy for development of 'a culture where the sciences are recognised as relevant to everyday life' as noted in Inspiring Australia's national strategy documents. This exhibition will showcase the importance of material science engineering to everyday life and familiar objects, as well as encouraging young people to pursue studies and careers in science and engineering. The exhibition is also closely aligned with major themes in the Australian National Science Curriculum from foundation year to year 10 (See Appendix 1), thus satisfying many of the educational needs of Australian students.

This exhibition was developed in line with the core values and strategies of Questacon and other science centres around Australia. The exhibition is portable and suitable for display in a versatile range of gallery spaces, requiring minimal staffing and using minimal consumable materials within exhibits. This makes the exhibition suitable for hire, travel and display by other science centres in Australia; likely candidates are Scitech in Western Australia and Scienceworks in Victoria, and possibly even internationally. This exhibition also has a large scope for potential partnerships and sponsorships. It incorporates one whole exhibit dedicated to showcasing the innovations in material science engineering by CSIRO, and they would be the first group to be approached for a major partnership in realising this exhibition. Potential sponsors include Gore-Tex®, whose novel waterproof breathable fabric is incorporated into one of the exhibits, and the Du Pont Company which produces Teflon®, which is also used in the exhibition. There are a plethora of further companies that could be approached for sponsorship as outlined in our market research report.

The visual style of the entire exhibition is distinctive and striking. The style aims to follow a modern interpretation of ‘retro’ to help show off some of the materials in an atmosphere where we are looking to the future. The stylistic accents of the theme compliment the exhibit structures: boxes will be constructed from a tubular stainless steel frame with panelling constructed out of polished checker plate with translucent acrylic shapes, illuminated from within (See Appendix 2). Graphic panels will be made of laminated plywood set in the same tubular stainless steel as the bases so sharp edges can be avoided and the same visual style can be maintained throughout the whole exhibition.

The combination of the striking visual style with the interactive nature of the exhibits, placed in the context of Australia’s need for such an exhibition make “Mighty Materials” an essential venture for any science centre. The content of the exhibition is built on strong practical science and is sure to capture the minds of Questacon’s target audience of families with eight to fourteen year olds.

Power Push

How do we move electricity?

Which crank is easiest to turn?

Turn the crank and see how many lights flash!

Conductivity is a measure of how easily something allows electricity to pass through it. Materials can conduct electricity because electricity moves as a flow of tiny particles called electrons. These particles are too small to see even with a microscope. Some materials hold onto these electrons and don't conduct electricity very well. These materials are called INSULATORS. Other materials allow electrons to move through them easily. These materials are called CONDUCTORS.

Which of these materials do you think conduct?

Materials can be engineered to conduct electricity better by adding things like metals and carbon nanotubes that help the electrons to move. Materials can also be engineered to be better insulators by adding things like plastic which slow down the flow of electrons.

Intended messages, educational philosophy and exhibit purpose

This exhibit aims to explore the property of conductivity of certain materials. It enables visitors to better understand the differences in conductivity between various materials and that the distinction is not as simple as something being a conductor or an insulator.

The philosophy of the exhibit incorporates constructivism, recognising that the best way to learn about something is to be surprised and 'hands-on'. In this case the different materials will be paired to have a pair that both look metallic (one copper and one brass), a pair that both look like a plastic (one being conductive plastic and graphite) and a pair that contains water of differing concentrations of ions. Due to the similar appearance we are envisaging that visitors will be surprised by the difference in the conductivity between the materials.

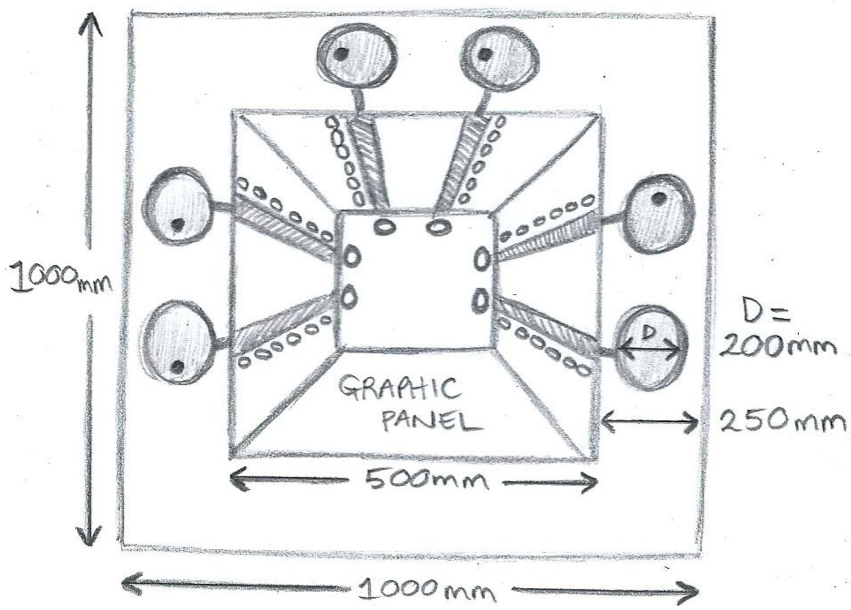
Through the visitors' interaction with the exhibit, we hope to trigger them to question why things that look similar act in different ways when exposed to outside influences. As each of the pairs of materials conducts for a different reason we will also have smaller graphics panels between the columns outlining the specific differences that allow one to conduct better than the other. This is due to the availability of electrons and ions as well as the structures of the materials.

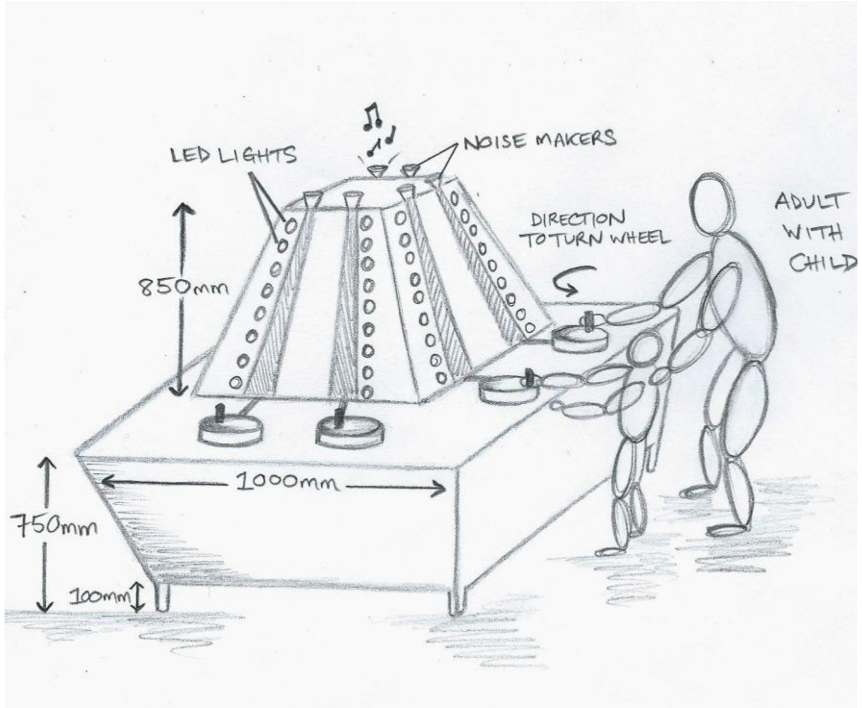
The user of the exhibit has a target goal, to get the lights and buzzer going, which we expect will help to increase visitor interaction time and encourage them to interact with the exhibit for long enough to absorb the graphic panel information.

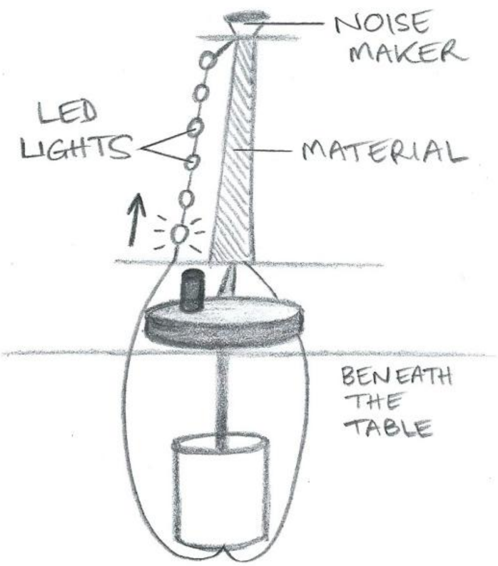
How a visitor uses this exhibit

A visitor will interact with the exhibit by turning the cranks. This will in turn generate a current and light up a series of LEDs that light up higher as more current is produced. The differences between the cranks are the 'wire' that connects the LEDs to the crank. As these are made of different materials of differing conductivity they will require different amounts of effort to light up the same number of LEDs, for example the graphite wire crank will be easier to turn then the iron wire crank.

The benefit of having multiple cranks is not just that an individual can turn each crank and feel the differences in the difficulty between them but that multiple users can all interact with the exhibit at the same time and even have a friendly competition. This competition should help to encourage visitors to 'pull in' others to use the exhibit as well as to decide which crank they would like to turn, and why. This should help reinforce the concept that cranks that are easier to turn are linked to materials that have better conductivity (i.e. electrons move through the material more easily, with less resistance).







Other Considerations

This exhibit does not require any permanent staffing and due to the ease of use and the method for communication, there should be little pressure on staff to explain why some of the materials are easier to use than others. This exhibit should not have any accessibility issues as the interaction method is simple. The exhibit is at an appropriate height to allow interaction by wheelchair users and small children.

The exhibit will be safe to use and will also be grounded so that if a build up of charge should occur somehow, it will be leaked to earth before it can do any harm to visitors. All of the electricity used in the exhibit is generated by the visitor during use. Using low power LEDs allows us to reduce the amount of current produced to keep it below a dangerous threshold. This also means that in the absolute worst case scenario where there is somehow a build up of charge, the visitor cannot be exposed to the hazard for an extended period.

Maintenance will be minimal, although if required it will most likely be through the replacement or repair of the crank system. The addition of a limiter to the generator should reduce this requirement as it will keep the device well within its normal working conditions. The hand cranks will sit in a fixed rail and be raised to prevent anyone from breaking through it into the generator, such as if a child was to jump on top of it. The exhibit contains no consumables and does not require a reset mechanism. To stop using it you just need to stop turning the crank and to start using it, you simply start turning the crank again. As there is no battery or capacitor system to keep the LEDs on while the crank is not being turned, there is no need for a mains connection or charging system. This allows the exhibit to be placed anywhere within an exhibition space with relative ease and it is also easily moved with a standard forklift due to the 100mm gap from the floor to the underside of the exhibit.

Dabbling With Density

Why would the density of materials be important for building things?

There are six cylinders made of different metals.

Carefully lift the different cylinders. Feel their weight. Some of them may surprise you!

Which ones might you choose to make heavy weights for a gym out?

Which ones might you choose to make an aeroplane or drink can out of?

Though the cylinders are all exactly the same size, the density of the materials they are made of is different, making the weight of each cylinder different.

Intended messages, educational philosophy and exhibit purpose

The objective of this exhibit is to encourage visitors to discover and explore the concept of density. This shall be done in a way that is safe, as interactive as possible, fun, surprising, accessible and intuitive to use for a wide range of different types of visitors.

The concept of density is highly relevant to materials science engineering. It is an important property of materials that must be factored into engineering decisions. Increasingly, novel materials with specifically engineered (often extremely low) densities are being developed. Examples of these materials, such as aerogel and metallic microlattices, are expected to perform well in many applications and may be far more widespread in the future.

As well as being a crucial concept relating to exciting cutting edge research, the idea of density can be linked to essentially every kind of material that people in the general public interact with in their daily lives. Many visitors may be familiar with and have a solid understanding of density as a property of materials, but may not have any experience interacting with materials with unusual densities. They also may not have had access to items that would enable them to effectively compare and contrast the densities of different materials. Density, in other words, is a concept that is equally applicable both to everyday matters many would be familiar with, and bizarre and amazing extremes.

Some younger visitors could already have an intuitive grasp of density from playing with large and light objects such as balls, foam, and plastic toys, and small and heavy ones such as keys, coins and rocks. They may thus understand that the weight of an item is not necessarily linked to its size, but may not yet have consolidated this knowledge into the conception of density as a formal relationship between the mass and volume of a material.

These aspects of density mean it has great potential as the key focus of an engaging, surprising and informative materials science engineering exhibit.

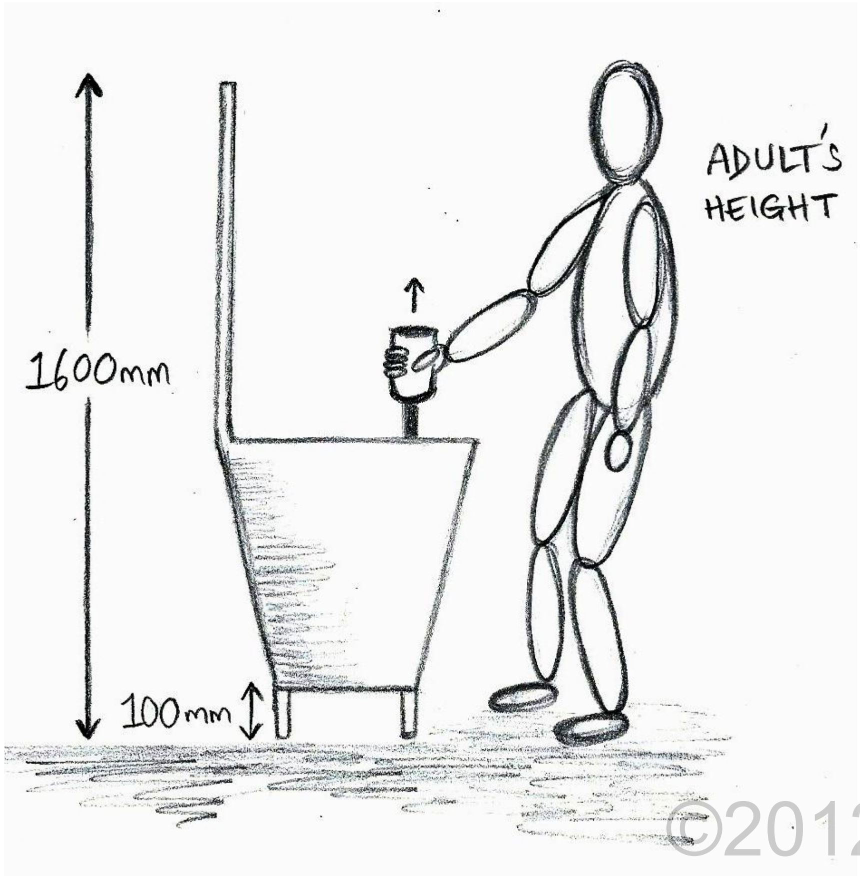
How a visitor uses this exhibit

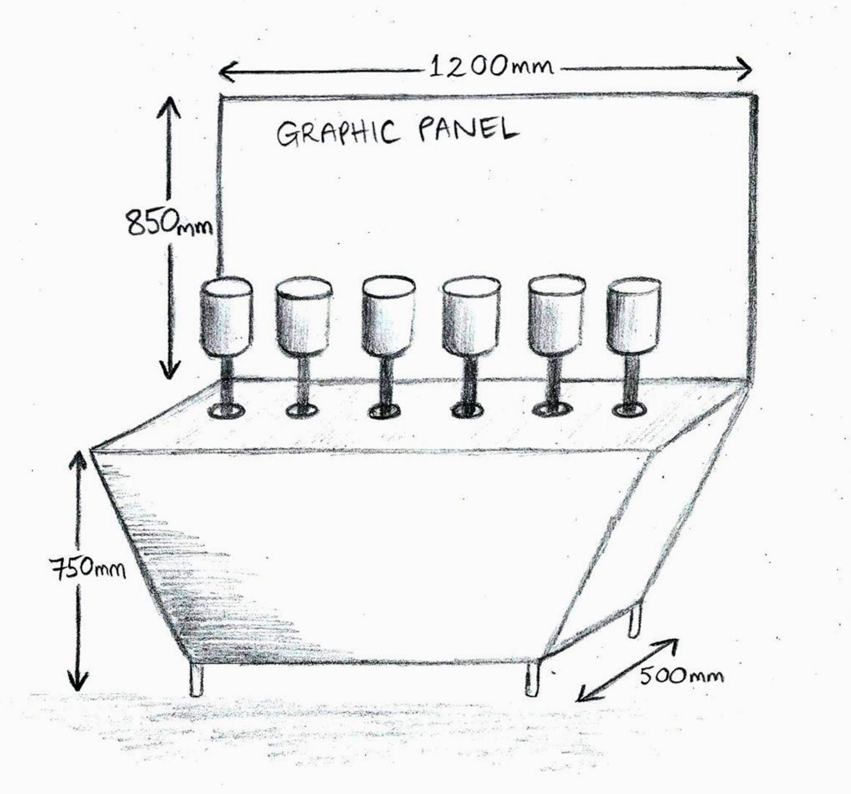
The exhibit would present examples of different metals with a range of density values in the form of cylinders, identical in size and shape. As an interactive exploration style exhibit, visitors would be free to grasp and lift the cylinders along a fixed vertical axis, feeling the entire weight of the cylinder. As all of the cylinders are very similar visually (due to all being lustrous metallic grey in colour and homogeneous in dimensions) there is the potential for visitors to be amazed and surprised by the weights of different cylinders.

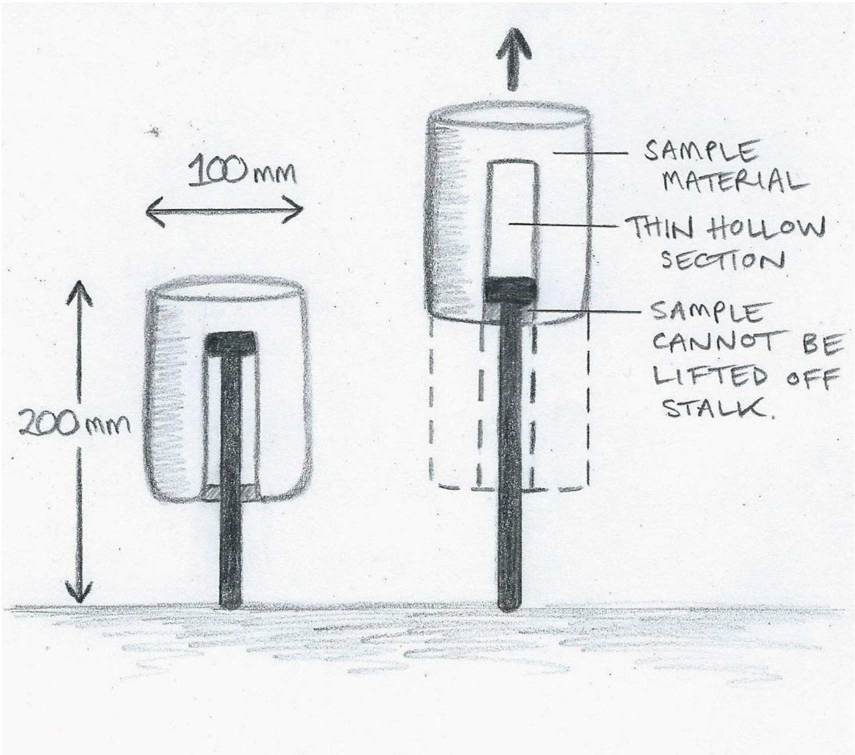
Many visitors might instinctively expect metal cylinders to have the weight of a common metal such as iron, meaning that significantly lighter or heavier metals would be particularly effective in capturing attention and eliciting a surprised and curious response. The visual and spatial similarity of the cylinders would emphasise that the weight difference between each one was due to the density of the material it was made of. Ideally, visitors would find this a memorable and unique way of exploring the concept of density.

To facilitate the objectives of the exhibit, the metals chosen for the cylinders would be magnesium, aluminium, titanium, iron, silver, tungsten, and iridium. These materials are all elemental metals, and have each been selected for various reasons: they represent a broad spectrum of densities; some are in very common use in everyday items; some are exotic whilst still being familiar; and some due to other factors (e.g. tungsten is very similar in density to gold, which would be too expensive and not durable enough to be featured). If necessary (due to being subject to extreme price fluctuations) the iridium cylinder could be omitted from the exhibit without significantly degrading its message and novelty. Tungsten, while somewhat less dense, is easily dense enough to be the densest material the average visitor will ever hold.

With cylinders five centimetres in diameter and ten centimetres tall, the least dense cylinder (magnesium) would be approximately 0.25 kg in weight, and the most dense (iridium) approximately 4.0 kg in weight. This is an extremely noticeable difference.




1200mm
GRAPHIC PANEL
850mm
750mm
500mm


100mm
200mm
SAMPLE MATERIAL
THIN HOLLOW SECTION
SAMPLE CANNOT BE LIFTED OFF STALK.

Other Considerations

Staffing requirements specifically for the exhibit are essentially negligible, as the exhibit is durable and simple to operate, and designed for relatively unguided group or solo exploration of a concept.

The design of the exhibit (as shown in diagrams and illustrations) mean that despite the fact that visitors can lift the full weight of each cylinder, their fingers and limbs cannot be pinched or crushed by the cylinders falling. Metals have been selected based on lack of toxicity and other dangers, though all cylinders would be coated with a thin transparent protective layer (Teflon® etc., depending on metal) for an added safeguard against allergies. Constructed with minimal moving parts made of very wear-resistant metals, the exhibit would be very durable and easy to maintain, bar extreme visitor abuse and catastrophic handling mishaps. The exhibit requires no consumables whatsoever. An effective reset mechanism is integrated into the basic design of the exhibit - when visitors stop interacting with it, its components are returned to default positions. Despite the extreme density of some sample materials, the exhibit as a whole would not be particularly heavy or cumbersome to move or relocate. This exhibit is very portable and easily moved with a standard forklift due to the 100mm gap from the floor to the underside of the exhibit. There is also no need for electrical wiring or any other form of power supply.

Set on a surface at a height consistent with other exhibits in the exhibition (as shown in diagram/illustration), the interactive elements of the exhibit would be easily accessible to a vast range of potential visitors. Visitors in wheelchairs would have no difficulty engaging with the exhibit. Very young children may be unable to lift the densest cylinders unaided, but this in itself assists in the demonstration of the core science messages of the exhibit, and may facilitate group interactions (such as a potentially disengaged parent being asked for assistance or challenged to take part by a child).

Blade Running

How would you run a race if you didn't have any legs?

Climb onto the platform and jump up and down. Feel the springiness of the carbon fibre blades which support the platform. Watch the platform while your friend jumps up and down. Try the platform with the wooden prosthetics.

How do you think these blades work to help disabled athletes run fast?

For thousands of years, humans have been losing limbs - whether in war, or to disease and infection. Clever scientists through the ages have been coming up with new technologies to replace those lost limbs. Modern athletes with a lower leg amputation can strap these J-shaped carbon fibre blades onto their lower limbs allowing them to run as fast as an able-bodied athlete. These blades may not look like a real leg, but the carbon fibre of the blades is engineered to be incredibly strong and flexible, made out of a plastic polymer reinforced by carbon fibres.

Does this platform feel different?

How do you think it would feel to run a race with wooden prosthetics?

Oscar Pistorius is a South African Olympic runner who was born with no bones in his lower legs. He runs using carbon fibre prosthetics like the ones in this exhibit.

You can see why his nickname is Blade Runner!

Intended messages, educational philosophy and exhibit purpose

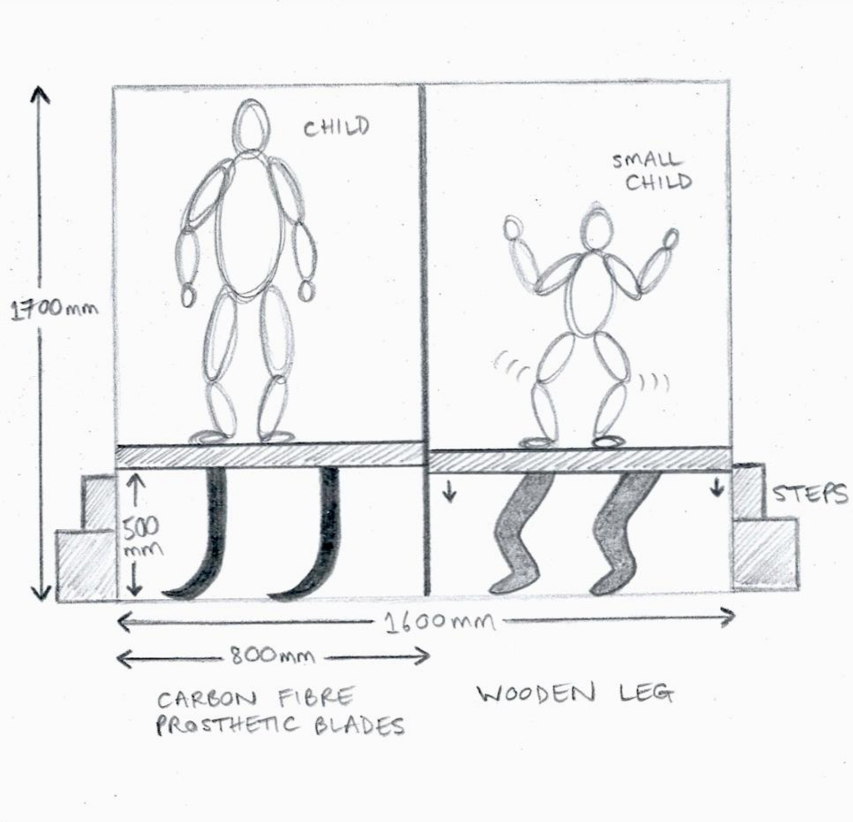
This exhibit is designed to provoke thought and discussion about the ways in which material science engineering can help people, specifically people who have limb amputations and use prosthetic limbs. Modern prosthetic limbs use a variety of materials which have been engineered to have specific properties such as flexibility and strength. Modern material science engineering can provide tools for people with physical impairments to live independently and to achieve highly in fields such as athletics. Early prosthetics were cosmetic in nature, and not particularly well engineered to achieve the same functions as the missing limb. The science and engineering of prosthetics has evolved over the years using novel materials and other technology such as hydraulics and electronics to restore much more of the function, as well as the form, of a missing limb.

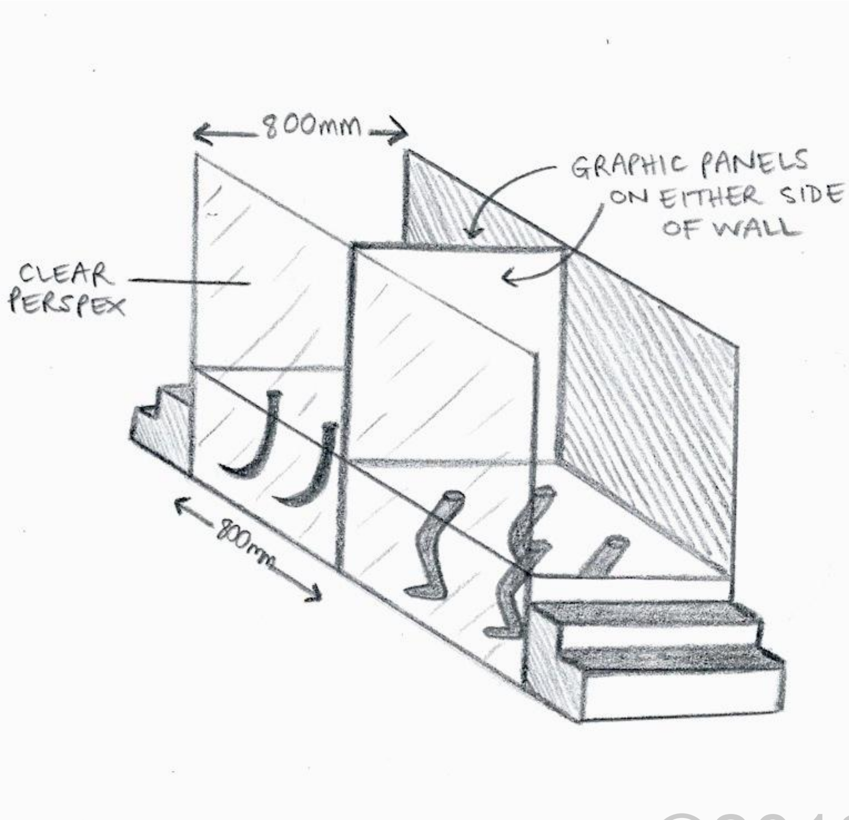
The example presented in this exhibit is the use of a particular material (carbon fibre) to restore the function of running to a person with a lower leg amputation. In particular, this exhibit focuses on experiencing the properties of carbon fibre which make it suitable for such an application – namely, its strength and flexibility. The J-shaped carbon fibre foot can also store energy and return it to the runner while running, like a human ankle and foot. This idea of engineering materials to fulfil or restore a biological function also links to the 'Printing with Plastic' exhibit which shares information about the printing of organs for human transplantation. The key messages of this exhibit are:

- Carbon fibre is a material which has been engineered to have incredible strength and flexibility.
- Material science engineering has developed over time, along with other engineering disciplines, to help restore lost biological functions such as running.

How a visitor uses this exhibit

Visitors stand on top of a platform which is supported either by J-shaped carbon fibre blades, similar to the prosthetic lower legs worn by elite athletes with lower leg amputations, or by older-style wooden prosthetics. The platforms can move up and down as the visitor jumps, allowing the visitor to experience the springiness, flexibility and strength of the carbon fibre blades and the comparative stiffness and inflexibility of the older prosthetics. The prosthetic-supported platforms will be surrounded by transparent enclosures allowing other visitors to observe the flexibility and deformation of the blades while the exhibit is in use. Hydraulic pistons support the platforms alongside the prosthetics, acting as a buffer and also restricting the movement of the platform in any direction except vertically up and down. The platforms are surrounded by transparent barriers on three sides with hand rails to allow visitors to hold on securely while the exhibit is in use.





Other Considerations

This exhibit does not require staffing and has no consumables. It is not suitable for use by some visitors with mobility impairment (for example, wheelchair users) as access to the platforms is by two steps up. However, all visitors are able to observe the prosthetics in use under the platforms. Platforms are engineered to eliminate finger traps and are stabilised by hydraulics as discussed above to allow movement in the vertical plane only. No sharp edges are present. The carbon fibre prosthetics used are engineered to support an athlete weighing up to 147kg; as this exhibit will include 4 prosthetics, this upper weight limit is effectively doubled to 294kg. Graphic panels incorporate safety warnings to ensure only one visitor at a time uses each platform. The hydraulic support system will reduce wear and tear on the prosthetics extending the life of the exhibit. The exhibit will fit easily through a double door (800mm depth). The transparent casing around this exhibit supports the communication of the key messages by allowing visitors to observe the mechanics of each type of prosthetic in action. The stairs will be checkerplate-clad to reinforce the visual connection with other exhibits.

Structurally Sound

Intended messages, educational philosophy and exhibit purpose

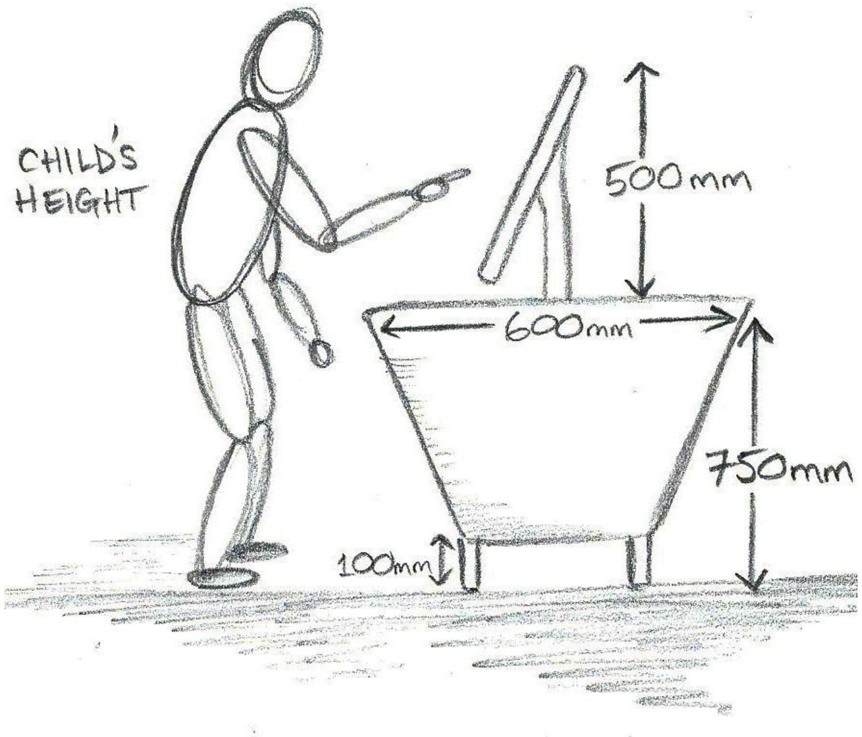
Everything is made up of atoms and these atoms can be arranged in different ways to change the structure and properties of a material. Crystallography is the study of the arrangement of atoms within solids and is an important part of understanding why certain solid materials exhibit certain properties. In this exhibit, visitors will explore the structures of carbon in three materials: diamond, graphite pencil and a carbon nanotube (within a microchip). Visitors will be given the chance to explore the difference in their structures by being able to 'zoom in' and look at electron microscope images of the materials, all the way to the atom.

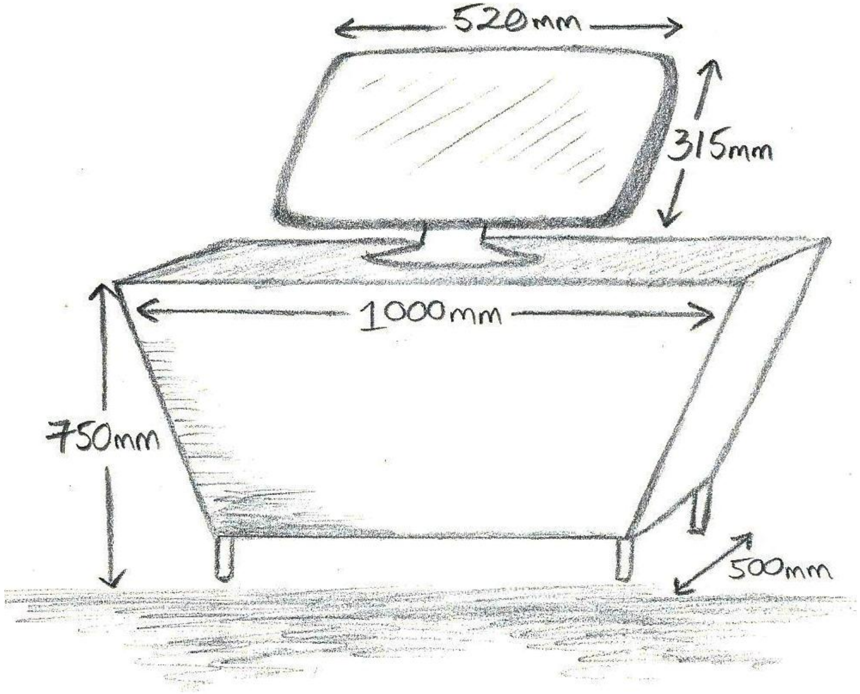
This exhibit will convey these key messages:

- That all materials are made up of atoms.
- The way that these atoms are arranged can determine the properties of a material, such as 'hardness' in diamonds or 'brittleness' in graphite.

How a visitor uses this exhibit

This will be a computer based exhibit with a 24 inch LCD touch screen at the bench height of 750mm.





The monitor will be at the angle of 20 degrees to the vertical axis to allow for easy viewing access for children and disabled (wheelchair) users and to also minimize reflection (although this will depend largely on the positioning of the lights in each venue).

This exhibit follows a similar system to that of an exhibit in the "Strange Matter" exhibition called 'Zoom'. An example of this Strange Matter exhibit, designed for internet use, can be found at http://www.strangematterexhibit.com/structure.html .

Visitors will see the following images on the welcome screen, which allows them to zoom in on any of the three materials. These graphics only show the outcome of if a visitor chose to zoom in on the diamond, although the options of a pencil and microchip will show the same text with different images. Visitors will see images and text like the following, although in reality there will be a continuous reel of photos as the visitor zooms in closer and closer.

STRUCTURALLY SOUND

Touch screen
to begin.

Touch one of these
carbon based items to
ZOOM in on its structure!

What makes
diamond so
strong?

Why is graphite
a good material
for drawing?

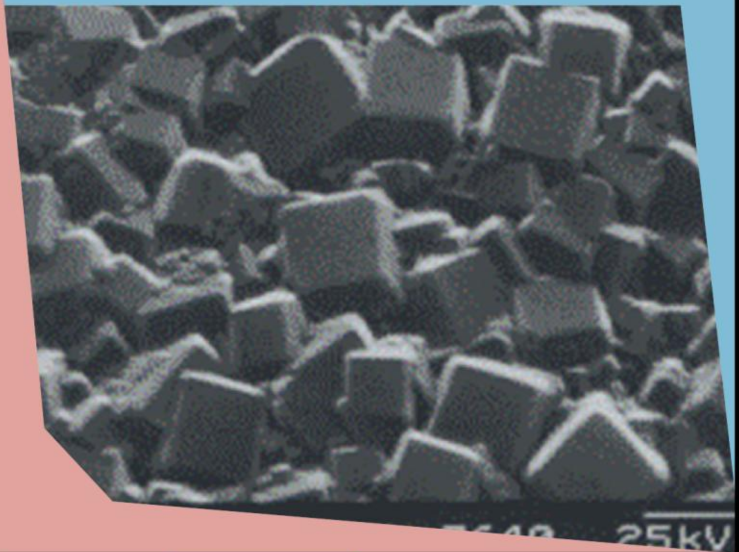
How can a
computer chip
be engineered
to be so small?

Use the slider at the bottom tozoom in on the
diamond's structure.

Use the slider to zoom in and out

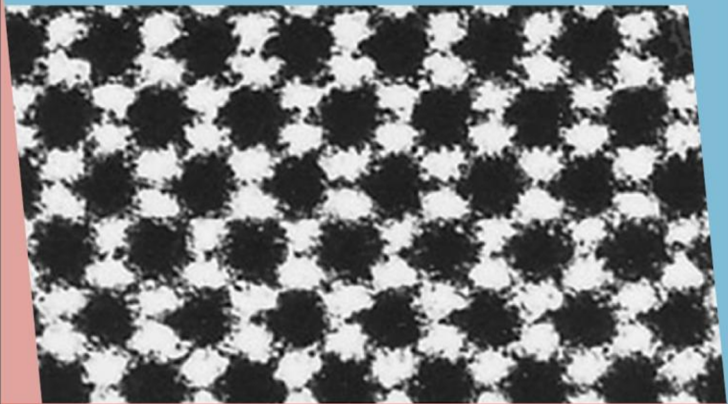
Return Home

These Structures are smaller than the width of a
human hair!



Return Home

Did you notice the atoms are organised in a repeating
pattern?

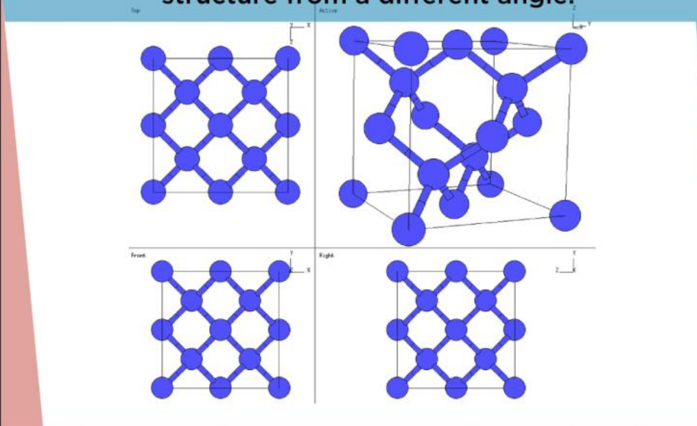


All materials are made up of atoms. It is how
these atoms are organized into a structure that
makes a material hard or soft, light or heavy, or
even strong or weak!

Return Home

Click here to see a
3D section of
this structure

Sliide your finger around the screen to see the
structure from a different angle.



The study of the arrangement of atoms is called
Crystallography. Materials Science Engineers can
sometimes change the properties of a material by
changing its structure, so we can use it for different

Return Home

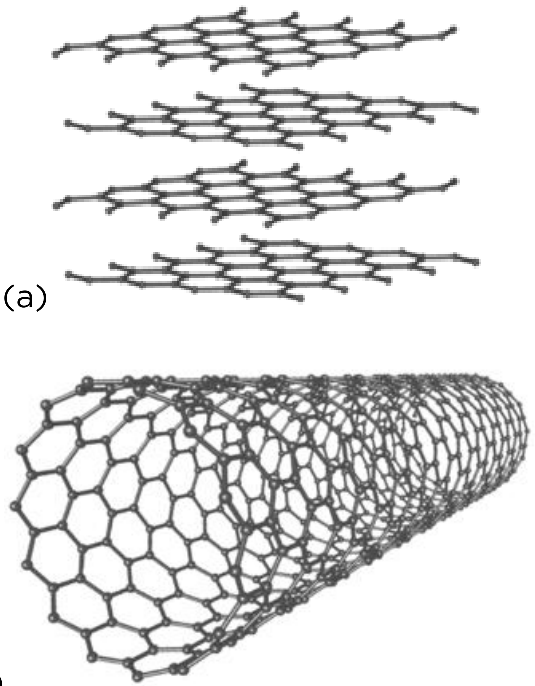
Compare
with Graphite

Compare with
Carbon Nanotubes

Once visitors reach the atomic level of the material, they can move their finger around the screen to see the atomic structure from different angles. They will not see the structure from all angles simultaneously (as seen in the flowchart). They will experience something more like this animation of the diamond's structure found at http://en.wikipedia.org/wiki/File:Diamond_Cubic-F_lattice_animation.gif

Electron microscope images will be gathered and used through the partnership with CSIRO. Electron microscopes use a beam of electrons to see things instead of using light, because you cannot see things that small using photons. Computer models of the atomic structures will be used to allow visitors to explore the structure from different angles.

If visitors choose to zoom in on the graphite pencil or the computer microchip, they will see electron microscope images zooming in on each material (similar as to the flowchart of the diamond) with the same non-specific text. They will eventually see the structures of graphite layers and a carbon nanotube respectively (Figure 1).



(a) (b)

Figure 1. Atomic structures of (a) graphite and (b) a carbon nanotube, respectively.

As with diamond, they will be able to slide their finger around the screen to see the structure from different angles. If visitors choose to compare structures using the appropriate touch screen button, the following text will appear to explain the difference in properties:

"These materials are both made from carbon atoms, so the difference in their properties is not due to what they are made from, it is how their atoms are arranged in their structure!"

"Graphite pencils are brittle because there is no bonding between their layers. When you draw, these layers slide off the pencil easily onto the paper."

"Carbon nanotubes are strong because there are lots of bonds between the carbon atoms, but they are also super small because the structure is only one atom thick!"

"Diamonds are so strong because of their lattice structure. There is lots of bonding between lots of atoms which makes it harder to break."

There is a button to send visitors back to the original welcome screen, although a reset mechanism will be in place so that if the exhibit is left untouched for ten seconds, it will return to the welcome screen for new visitors to engage with.

Other Considerations

There are no staffing requirements or consumables for this exhibit. There will be no sharp edges or areas where fingers could be trapped. The exhibit does not require excessive strength required to drive it, therefore the main safety consideration concerns hygiene. Regular antibacterial cleaning of the touch screen must occur to ensure safe hygiene practices, as this exhibit will have plenty of different people's fingers touching it. In terms of potential fire safety issues, there should be adequate ventilation for the computer parts of this exhibit and regular dusting should occur to ensure its effective operation.

Although this exhibit is very portable and easily moved with a standard forklift due to the 100mm gap from the floor to the underside of the exhibit, it does need access to a power source. This may mean that its placement within any exhibition space will be limited to near a power point. The exhibit can easily fit through a single door (500mm width) and will be relatively lightweight to move. Touch screens have a lifespan of several years, but this varies with usage levels. Maintenance may be needed to keep the touch screen in working order and it may need to be completely replaced at some point. Using a screen protector could be considered to maximize the life of the touch screen. No major design features are used as communication supports, although certain materials (e.g. checkerplate) have been used to emphasise the 'materials' aspect of the whole exhibition.

Additional Exhibits

Bridging the Gap

This exhibit is designed to take a visitor through the process of engineering a common material (paper) to suit a specific purpose – building a bridge over a gap to support a weighted toy car. This exhibit is intended to demonstrate that even everyday materials (such as paper) can have their structure changed to alter their properties – for example, paper is generally a flimsy material but can be bent and shaped in such a way that it is able to support a surprisingly large amount of weight. The structure of the material can be altered on a macro level to change its properties.

This exhibit guides visitors through a process similar to that which material science engineers go through when engineering materials to have specific properties. Only paper is provided – no sticky tape or other adhesives – this reflects the fact that engineers are often constrained by the materials available to them. Paper is a cheap consumable and is easily available. This exhibit will require minimal staffing to periodically replenish supplies of paper.

Graphic panels for this exhibit will display a variety of challenge questions: Can you use fewer materials to build the bridge? Can you make the bridge lighter while still being able to support the car? How might you make the bridge more durable or longer lasting? This is an open ended exhibit which supports exploration and has no “right” or “wrong” answer.

Processing Power

This exhibit shows that the properties of materials can be changed through combinations of different processes such as chemical processing, heat and pressure. These are techniques which humans have successfully used for thousands of years to engineer materials and these techniques are still used today to change the properties of materials.

This exhibit will follow the popular ‘feel’ of the Gravitram exhibit in the foyer of Questacon. Visitors will be able to select from a variety of models of ball-shaped “raw starting materials” including coal, isoprene (natural, untreated rubber), glucose (sugar) and iron. Visitors can then use buttons on a display panel to select one or more treatments for their chosen starting material – chemical processing, heat processing or pressure/physical deformation – and see the effect their chosen treatment has upon the starting material. Starting materials will be represented by balls with printed labels and graphics to show which starting material is represented by each object and give some information about the starting material. The balls will contain RFID tags to allow identification by the exhibit when the ball is deposited into a ball run. The “starting material” ball will go through a ball run which lights up as the ball goes through the selected “treatment” areas of the ball run. Finally, a “processed material” ball will drop out of the exhibit allowing the visitor to pick it up and read about the material they have created through their starting material and processing choices. This exhibit will not require constant staffing, although staff will have to ensure that "processed material" balls are returned to the exhibit.

Digging Deep

This full body immersive, information-based exhibit is designed to communicate the idea that material science engineering is not just about modern, cutting edge technologies for shaping the properties of materials – rather, humans of all cultures have been engineering materials for thousands of years, starting with wood, stone, metals and ceramics. The exhibit is designed as a walk-through cave, with various historical artefacts (wooden, Stone and Bronze age tools, kitchen equipment and weapons) displayed as though they were part of an archaeological dig, which visitors can handle. As visitors interact with the objects on display, motion sensing technology turns on lights to illuminate the area of the artefact and a short audio narration plays, describing how earlier humans engineered materials to make that particular artefact. This exhibit will include artefacts demonstrating the technologies of Australian Indigenous cultures, providing links to the new National Curriculum.

Bricks and Blocks

Designed for younger visitors aged 0-6, this exhibit will feature building blocks of several different materials including wood, foam and plastic. These building blocks will come in a variety of shapes and sizes. This exhibit is designed to allow exploration and free play using different materials, and to promote independent or social discovery about the properties of these different materials and how they can be used to build a variety of structures. Young visitors can exercise creativity in building their own structures. The accompanying graphic panel will display a range of challenge questions such as "Which blocks are good for building a high tower? Which blocks are hardest? Which blocks are good for building strong walls?" which supervising adults can use to interact and engage with young visitors, enhancing the free play experience. This exhibit will not require staffing as younger visitors should be supervised by an adult at all times.

Printing with Plastic

This exhibit puts new technologies in the spotlight by displaying a 3D printer in action. This exhibit is designed to show the exciting possibilities of new technologies such as 3D printing, and the benefits they bring to our society. From the convenience of printing replacement parts instead of ordering them in, to the eco-friendliness of recycling possibilities (imagine feeding a broken part into the machine for it to be melted down and remade!), these machines are the way of the future. Visitors will use this exhibit by pressing a button to make the machine print for 20 seconds, thus reducing waste by not printing at all times when there are no visitors to observe. The printer will be accompanied by a touch screen explaining the process and some more applications of this technology, and visitors may be able to purchase items (puzzles etc.) which have been printed on the machine, to take home and share. This exhibit also shows that there are many properties of a material which can be engineered – as well as engineering materials to be light or strong; they may also be engineered to be portable or recyclable, depending on the requirements of the project. The touch screen will include information on developments in biomedical engineering, which is starting to use 3D printers to “print” organs for use in human transplantation which is a totally new application of this technology.

Cleverly Clothed

This exhibit will demonstrate to visitors that materials science engineering is not just focused on large-scale industry or civil engineering projects. Even the clothes we wear are “engineered”. When making clothes, one must consider structure, the properties of materials available, and take into account the specific purpose they are designed for. Visitors can experience and learn about some of these factors as they apply to both everyday and specialised garments.

As a full body immersive exhibit, several different types of large jackets would be provided for visitors to try on. The exhibit features various ways to test specific jackets, such as a heat lamp that can be temporarily turned on for visitors to test the properties of a fireman's coat, or a fan to test the material’s use in breezy conditions. Other dress-up options include identically-shaped jackets made of fake and real leather, challenging visitors to find the differences and think about the properties of each one, as well as jackets made of Gore-Tex® (a potential sponsor) as they have developed a novel fabric which is waterproof and breathable. Interesting non-wearable artefacts such as a shirt of chain mail could also be present for display only, as it is far too heavy for Questacon’s young target audience to wear.

Titanic Tension

This exhibit aims to surprise and engage visitors with state-of-the-art materials science engineering. An unexpectedly and amazingly thin carbon fibre cable holds up a usable chair swing hanging from a sturdy frame. As well as being a full body immersive exhibit for those on the swing, it would be surprising for onlookers. Visitors watching from a distance would see people appearing to hang and swing in the air from nothing, due to the tiny diameter and dark colour of the cable.

By being surprising and physically engaging, this exhibit can capture the attention of visitors, and impart the message that materials science engineering can result in some extremely strong materials that defy our expectations. The tensile strength and weight of the cable will be shown along with an example of how much thicker and heavier a steel cable needs to be to have the equivalent tensile strength. This exhibit aims to be memorable and striking, creating a word-of-mouth buzz to drive visitor numbers.

Material Messages

There are many techniques in material science engineering that are impossible or impractical to develop into physical interactive exhibits; this video exhibit offers a way to display these impressive and interesting concepts and techniques. The exhibit would primarily be a large screen showing a looping series of brief videos concerning diverse phenomena related to materials science engineering past present and future. Examples of different segments would include re-enactments of the process of shaping of ancient stone tools, glass blowing, jewellery making, stress testing different materials (crushing in slow motion etc.), examples of biomimicry and an aerogel block balancing on an open flame. Sparse text would accompany some videos, explaining what is shown and reiterating key communication messages of the Mighty Materials exhibition.

As well as compiling topics unable to be shown in a traditional exhibit, the more passive nature of a video exhibit is likely to be a welcome change of pace for visitors from the many exciting full body immersive exhibits. Basic seating would be located near the video display.

Slip or Grip

This exhibit consists of multiple ramps of the same angle, all made of iron treated in different ways. Visitors could take part in a race in which they slide identical blocks down each of the ramps to see which one gets to the bottom first. The “fastest” ramp would be the ramp made of the material having the lowest coefficient of friction.

Ramps would be plain wrought iron, stainless steel, industrial diamond/checker plate textured steel, and steel coated in Teflon®. The exhibition would thus explain that the process of engineering and reworking (by alloying, polishing, embossing, coating and treating etc.) may result in materials that have the same bulk compositions but very different properties, as well as demonstrating the variable friction of different surfaces.

DuPont, the American chemical company that markets polytetrafluoroethylene as Teflon®, could be contacted as a potential sponsor.

Aussie Innovation

Australian scientists at CSIRO have been involved in developing some amazing materials. This exhibit showcases Australian material science innovation and achievement to support the Inspiring Australia initiative. It is recommenced that the CSIRO is approached as a potential partner, thus the partnership would entail exhibiting recent their research work, such as flexible printable solar cells.

This simple exhibit allows visitors to discover Australian innovation by lifting a flap displaying a photograph of a material. This will reveal a few sentences about the development of that particular material. This exhibit will inspire surprise when visitors discover all the technological examples were developed in Australia. Plastic banknotes, biomedical implants and flexible solar cells are examples of the CSIRO material science technologies which could be included in this exhibit. The key message of this exhibit is to emphasise that Australian scientists, in particular the CSIRO, are at the forefront in material science engineering. This exhibit allows group interaction and discussion.

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Appendix 1 - Table of instances where the National Science Curriculum (Foundation to year 10) crosses over with our Materials Science Engineering exhibition.

	Science Understanding	Science as a Human Endeavour	Science Inquiry Skills
Foundation Year	Objects are made of materials that have observable properties (ACSSU003) • sorting and grouping materials on the basis of observable properties such as colour, texture and flexibility • investigating different forms of clothing used for different activities	Science involves exploring and observing the world using the senses (ACSHE013) • recognising that observation is an important part of exploring and investigating the things and places around us • sharing observations with others and communicating their experiences	Respond to questions about familiar objects and events (ACSIS014) • considering questions relating to the home and school and objects used in everyday life Explore and make observations by using the senses (ACSIS011) • using sight, hearing, touch, (taste – **not in this exhibition**) and smell so that students can gather information about the world around them
Year 1	Everyday materials can be physically changed in a variety of ways (ACSSU018) • predicting and comparing how the shapes of objects made from different materials can be physically changed through actions such as bending, stretching and	Science involves asking questions about, and describing changes in, objects and events (ACSHE021) • recognising that descriptions of what we observe are used by people to help identify change	Respond to and pose questions, and make predictions about familiar objects and events (ACSIS024) • thinking about "What will happen if......?" type questions about everyday objects and events • using the senses to explore the local

	twisting	People use science in their daily lives, including when caring for their environment and living things (ACSHE022) • considering how science is used in activities such as cooking, fishing, transport, sport, medicine and caring for plants and animals • considering that technologies used by Aboriginal and Torres Strait Islander people require an understanding of how materials can be used to make tools and weapons, musical instruments, clothing, cosmetics and artworks	environment to pose interesting questions and making predictions about what will happen Participate in different types of guided investigations to explore and answer questions, such as manipulating materials, testing ideas, and accessing information sources (ACSIS025) • manipulating objects and making observations of what happens
Year 2	Different materials can be combined, including by mixing, for a particular purpose (ACSSU031) • exploring the local environment to observe a variety of materials, and describing ways in which materials are used • suggesting why different parts of everyday objects	Science involves asking questions about, and describing changes in, objects and events (ACSHE034) • suggesting how everyday items work, using knowledge of forces or materials People use science in their daily lives, including when	Respond to and pose questions, and make predictions about familiar objects and events (ACSIS037) • using the senses to explore the local environment to pose interesting questions, make inferences and predictions • thinking about 'What will

	such as toys and clothes are made from different materials • identifying materials such as paper that can be changed and remade or recycled into new products	caring for their environment and living things (ACSHE035) • exploring how different cultures have made inks, pigments and paints by mixing materials • recognising that many living things rely on resources that may be threatened, and that science understanding can contribute to the preservation of such resources	happen if...?' type questions about everyday objects and events Participate in different types of guided investigations to explore and answer questions, such as manipulating materials, testing ideas, and accessing information sources (ACSIS038) • manipulating objects and materials and making observations of the results • sorting objects and events based on easily identified characteristics
Year 3	A change of state between solid and liquid can be caused by adding or removing heat (ACSSU046) • predicting the effect of heat on different materials Heat can be produced in many ways and can move from one object to another (ACSSU049) • exploring how heat can be transferred through	Science knowledge helps people to understand the effect of their actions (ACSHE051) • considering how heating affects materials used in everyday life • investigating how science helps people such as nurses, doctors, dentists, mechanics and gardeners • considering how materials including solids and liquids affect the	With guidance, identify questions in familiar contexts that can be investigated scientifically and predict what might happen based on prior knowledge (ACSIS053) • jointly constructing questions that may form the basis for investigation

	conduction	environment in different ways • deciding what characteristics make a material a pollutant	
Year 4	Natural and processed materials have a range of physical properties; These properties can influence their use (ACSSU074) • describing a range of common materials, such as metals or plastics, and their uses • investigating a particular property across a range of materials • selecting materials for uses based on their properties • considering how the properties of materials affect the management of waste or can lead to pollution	Science involves making predictions and describing patterns and relationships (ACSHE061) • exploring ways in which scientists gather evidence for their ideas and develop explanations Science knowledge helps people to understand the effect of their actions (ACSHE062) • investigating how a range of people, such as clothing designers, builders or engineers use science to select appropriate materials for their work	With guidance, identify questions in familiar contexts that can be investigated scientifically and predict what might happen based on prior knowledge (ACSIS064) • considering familiar situations in order to think about possible areas for investigation

Year 5	Solids, liquids and gases have different observable properties and behave in different ways (ACSSU077) • recognising that substances exist in different states depending on the temperature • recognising that not all substances can be easily classified on the basis of their observable properties	Scientific understandings, discoveries and inventions are used to solve problems that directly affect peoples' lives (ACSHE083) • investigating how the development of materials such as plastics and synthetic fabrics have led to the production of useful products	With guidance, pose questions to clarify practical problems or inform a scientific investigation, and predict what the findings of an investigation might be (ACSIS231) • applying experience from similar situations in the past to predict what might happen in a new situation
Year 6	Changes to materials can be reversible, such as melting, freezing, evaporating; or irreversible, such as burning and rusting (ACSSU095) • describing what happens when materials are mixed • investigating the change in state caused by heating and cooling of a familiar substance • exploring how reversible changes can be used to recycle materials Electrical circuits provide a means of transferring and	Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena (ACSHE098) • investigating how knowledge about the effects of using the Earth's resources has changed over time Scientific understandings, discoveries and inventions are used to solve problems that directly affect peoples' lives (ACSHE100)	With guidance, pose questions to clarify practical problems or inform a scientific investigation, and predict what the findings of an investigation might be (ACSIS232) • asking questions to understand the scope or nature of a problem • applying experience from previous investigations to predict the outcomes of investigations in new contexts

	transforming electricity (ACSSU097) • investigating different electrical conductors and insulators	• investigating how electrical energy is generated in Australia and around the world	
Year 7	Mixtures, including solutions, contain a combination of pure substances that can be separated using a range of techniques (ACSSU113) • recognising the differences between pure substances and mixtures Some of Earth's resources are renewable, but others are non-renewable (ACSSU116)	Scientific knowledge changes as new evidence becomes available, and some scientific discoveries have significantly changed people's understanding of the world (ACSHE119) Science knowledge can develop through collaboration and connecting ideas across the disciplines of science (ACSHE223) People use understanding and skills from across the disciplines of science in their occupations (ACSHE224)	Identify questions and problems that can be investigated scientifically and make predictions based on scientific knowledge (ACSIS124) • using information and knowledge from previous investigations to predict the expected results from an investigation
Year 8	The properties of the different states of matter can be explained in terms of the motion and arrangement of particles (ACSSU151) • explaining why a model for the structure of	Scientific knowledge changes as new evidence becomes available, and some scientific discoveries have significantly changed people's understanding of the world (ACSHE134)	Identify questions and problems that can be investigated scientifically and make predictions based on scientific knowledge (ACSIS139) • using information and knowledge from their own

	matter is needed • modelling the arrangement of particles in solids, liquids and gases Differences between elements, compounds and mixtures can be described at a particle level (ACSSU152) • modelling the arrangement of particles in elements and compounds	Science knowledge can develop through collaboration and connecting ideas across the disciplines of science (ACSHE226) People use understanding and skills from across the disciplines of science in their occupations (ACSHE227)	investigations and secondary sources to predict the expected results from an investigation
Year 9	All matter is made of atoms which are composed of protons, neutrons and electrons; natural radioactivity arises from the decay of nuclei in atoms (ACSSU177) Chemical reactions involve rearranging atoms to form new substances; during a chemical reaction mass is not created or destroyed (ACSSU178)	Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries (ACSHE158) Advances in science and emerging sciences and technologies can significantly affect people's lives, including generating new career opportunities (ACSHE161) • recognising aspects of science, engineering and technology within careers such as	Formulate questions or hypotheses that can be investigated scientifically (ACSIS164) • developing ideas from students own or others' investigations and experiences to investigate further

		medicine, medical technology, telecommunications, biomechanical engineering, pharmacy and physiology The values and needs of contemporary society can influence the focus of scientific research (ACSHE228)	
Year 10	The atomic structure and properties of elements are used to organise them in the Periodic Table (ACSSU186) • investigating the chemical activity of metals Different types of chemical reactions are used to produce a range of products and can occur at different rates (ACSSU187) • investigating how chemistry can be used to produce a range of useful substances such as fuels, metals and pharmaceuticals	Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries (ACSHE192) Advances in science and emerging sciences and technologies can significantly affect people's lives, including generating new career opportunities (ACSHE195) • predicting future applications of aspects of **nanotechnology** on people's lives The values and needs of contemporary society can influence the focus of scientific research (ACSHE230)	Formulate questions or hypotheses that can be investigated scientifically (ACSIS198) • developing ideas from students own or others' investigations and experiences to investigate further

Appendix 2: Colour Swatches and Design Materials

Taubmans
Planetarium 43F.1
50%

Taubmans
Crossfire 19C.2

Taubmans
Crossfire 19C.2
50%

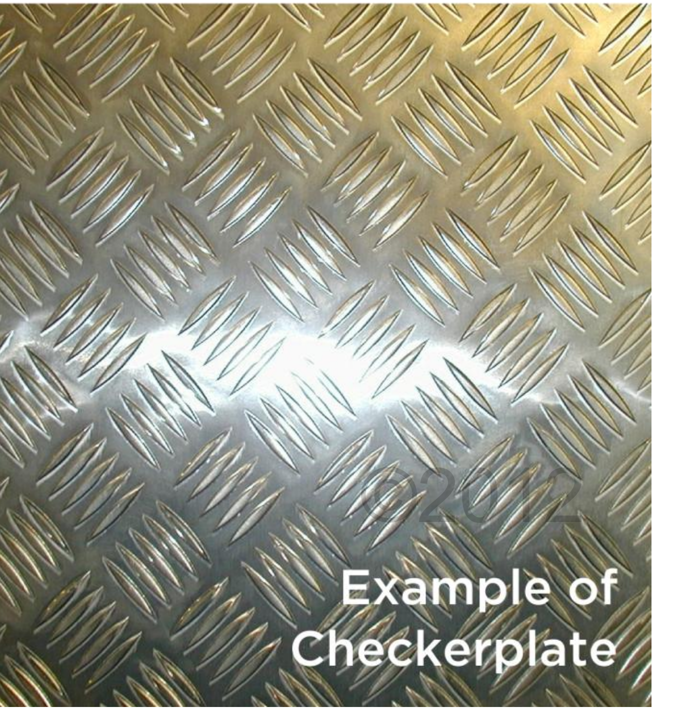
Taubmans
Planetarium 43F.1

General Materials.

Box Paneling:
- Translucent White Acrylic
- Polished Checkerplate Steel or Aluminium

Box Frames:
- Rolled Tubular Stainless Steel

Graphics Panels:
- 10mm Laminated Plywood



Example of Checkerplate

MIGHTY MATERIALS