Further guidance

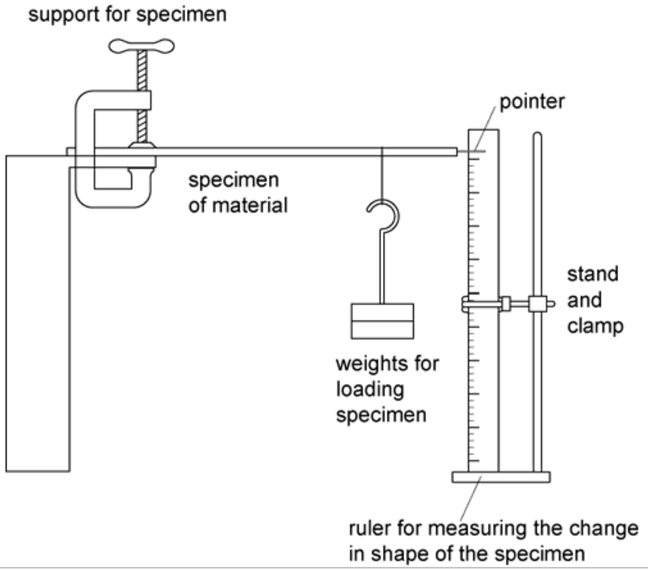
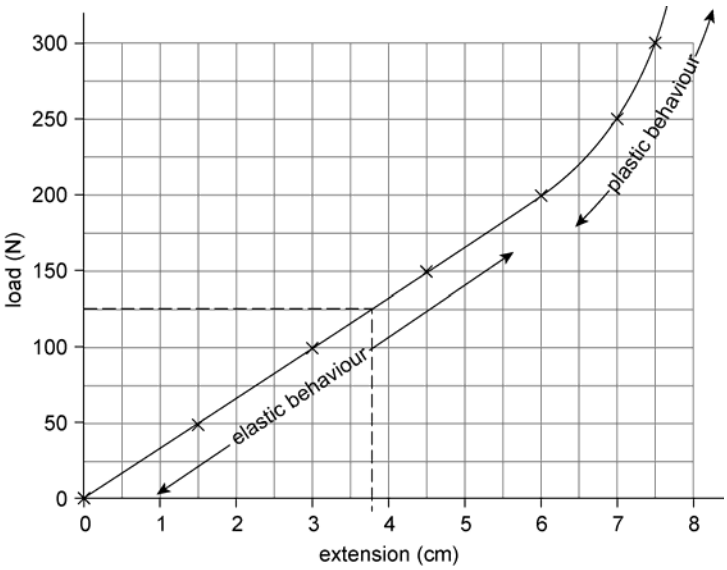
Contents

There are no further activities or notes associated with this module.

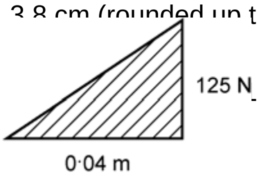
A6 Materials and performance – Workbook answers

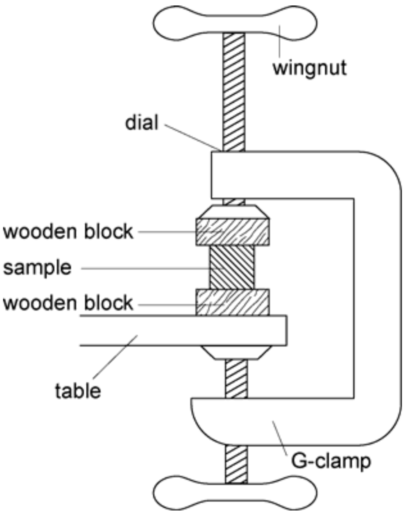
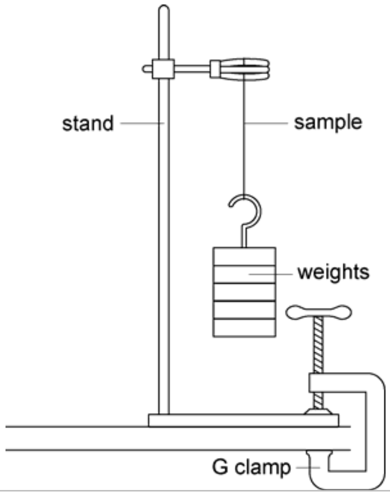
<table>
<tr><td>1</td><td>a</td><td></td><td>Design engineers, marketing experts, managers, instructors and trainers, electronics engineers</td></tr>
<tr><td></td><td>b</td><td></td><td>
<table>
<tr><th></th><th>Food packaging</th><th>Overcoat</th><th>Car tyre</th></tr>
<tr><td>Most important factor</td><td>performance</td><td>aesthetic appeal</td><td>performance</td></tr>
<tr><td></td><td>cost</td><td>cost</td><td>environmental impact</td></tr>
<tr><td></td><td>aesthetic appeal</td><td>performance</td><td>cost</td></tr>
<tr><td></td><td>environmental impact</td><td>durability</td><td>durability</td></tr>
<tr><td>Least important factor</td><td>durability</td><td>environmental impact</td><td>aesthetic appeal</td></tr>
</table>
</td></tr>
<tr><td></td><td>c</td><td>i</td><td>Safe, good quality, always made to the same standard</td></tr>
<tr><td></td><td></td><td>ii</td><td>BSI, CE, ISO</td></tr>
<tr><td></td><td></td><td>iii</td><td>Two examples, e.g. Trading Standards Inspector, Buildings Inspector</td></tr>
<tr><td></td><td>d</td><td></td><td>Fore example:
Product – seams on a teddy bear
Safety margin – 70 N is about 10 times the force a toddler could use on the seams, normally</td></tr>
<tr><td></td><td>e</td><td></td><td>• A stiff material — does not change shape much when loaded.
• A hard material — doesn’t scratch very easily.
• A tough material — absorbs a lot of energy before it breaks.
• A brittle material — changes shape very little before it breaks.
• A strong material — only breaks under lots of loading.
• A dense material — has a lot of mass for a small volume.
• A flexible material — changes shape a lot when it is loaded.</td></tr>
<tr><td>2</td><td>a</td><td></td><td>Missing words: malleable, rigid, durable</td></tr>
<tr><td></td><td>b</td><td></td><td>• Loading a material in tension — make it longer.
• Loading a material in compression — makes it shorter.</td></tr>
</table>

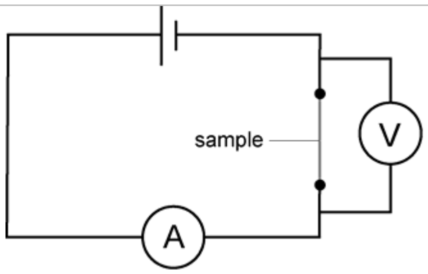
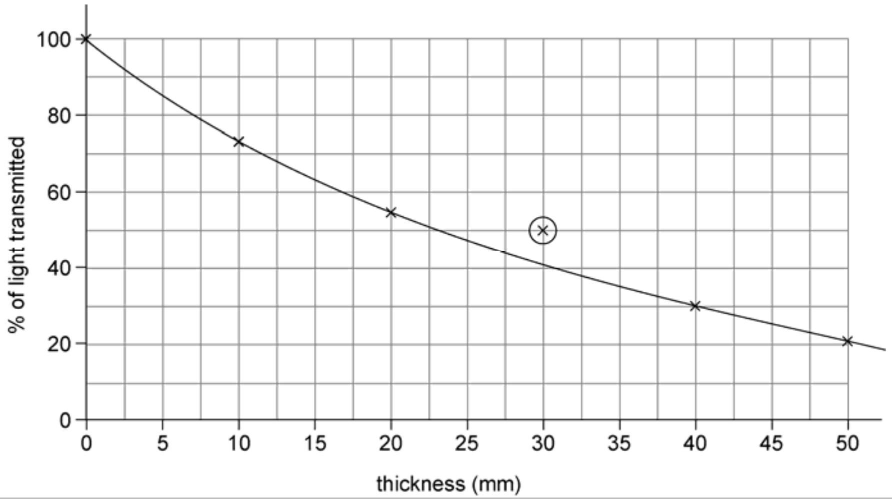
Further guidance

	c		For example: I would set up the equipment as shown I the diagram. I would start with no weight on the specimen and put the ruler so the pointer is at zero. Then I'd add a weight and write down the number nearest the pointer. I'd keep adding weights until I'd done 6 readings. Then I would test the other sample in exactly the same way. If I had enough time I would try the test again to check the readings. 
	d	**i**	Missing words: elastic, plastic
		ii	

Further guidance

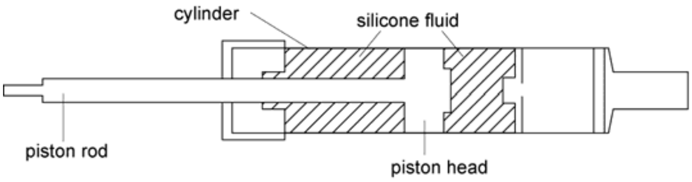
		iii *	• 3.8 cm (rounded up to 4 cm for subsequent calculations) • .5 N/cm • Extension = 4 cm = 0.04 m Energy = area of triangle under graph = ½ base x height = 1.2 x 0.04 m x 125 N = 0.02 x 125 = 2.5 J
	e		For example: • cross-pieces between the legs would make it stronger • a different type of plastic could be used, which is stiffer • the legs could have a tubular cross-section • making the components thicker will make the chair more rigid
3	**a**	**i**	Velocity is rate of change of distance in a particular direction.
		ii	Momentum is proportional to both mass and velocity.
		iii	…in the direction of the force
	b	**i**	change in momentum = mass x change in velocity
		ii	Crumple zones, cycle helmets, seat belts
		iii	Missing words: velocity, momentum, momentum, force, momentum, time, force
		iv	For example: foam lining – absorbs energy; hard outer shell of PVC – spreads force
	c*	**i**	The force on car A is greater than the force on car B, but it acts for a shorter time. The change in momentum is the same for both cars, so the product '*Ft*' must be the same – if you calculate average force x time you will get the same answers. But *F* is bigger and *t* is smaller for car A. That's why the graph looks like a peak not a hump.
		ii	change in momentum = $m(v - u)$ = 1500 kg x 14 m/s = 21 000 kg.m/s
		iii	• Car A force = 21 000 kg.m/s / 0.1 s = 210 000 N • Car B force = 21 000 kg.m/s / 0.3 s = 70 000 N
	d*		For example: • An upholstered chair made of wood with cushions covered in PVC fabric. The wood is strong and stiff. The PVC is flexible. • A climbing rope with a nylon core and a polyester sheath. The nylon core is strong in tension. The polyester sheath is tough.

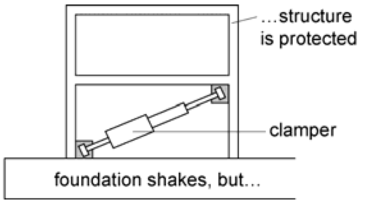
4	**a**		For example: I would set up the equipment as shown in the diagram. I'd put a dial under the wing nut and set it at 0 then I'd turn the wing nut until the sample crumbles. I'd record the number on the dial. 
	b		For example: I would set up the equipment shown in the diagram, but I'd start with just one weight and add weights one at a time until the sample snaps. I would record how many Newtons made it snap. 
	c	**i**	• Thermal expansion of a sample — tells you how much it expands when it heats up. • Thermal conductance of a sample — tells you how easily heat flows through it. • Electrical conductance of a sample — tells you how easily electricity flows through it.

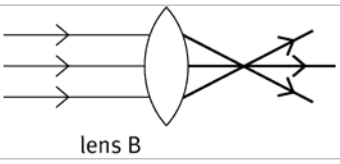
		ii*	 I would need to measure the current flowing through the sample, and the voltage across it. I would do this several times to check the reliability of the observations. Then I would calculate the electrical conductance by dividing the current by the voltage, e.g. if current = 0.5 A and voltage = 5 V, conductance = 0.5 A / 5 V = 0.1 S
	d	**i** **ii** **iii**	
		iv	90 %
		v	% light transmitted = 100 – 1.74 x 3 = 100 – 5.22 = 94.6%
		vi	Not quite the same
		vii	91%
		viii	• similar • may not be reliable
	e*	**i**	Missing words: stiff, brittle
		ii	Missing words: weak, flexible
5	**a**		Missing words: cold, heat, easily, temperature, thermal, warm, hand, unchanged
	b	**i**	• Good thermal conductance: ice-freezing tray, frying pan • Poor thermal conductance: cuddly toy, hot water bottle, oven glove, blanket, house wall

Further guidance

		ii	• Loft insulation is used — to stop heat escaping from a house. • Car radiators are made of metal — to help heat get out of the engine. • Saucepan bodies are made from metal — to help heat flow quickly from source to food. • Refrigerators are lined with foam plastic — to stop heat getting in easily. • Saucepan handles are made from plastic — to stop your hand getting too hot.
	c*	**i**	For example: a bimetallic strip, used as a switch inside an iron. One side is made of a high expansion alloy and the other side is a low-expansion alloy. The strip bends because one side expands more. This breaks the circuit and stops the iron overheating.
		ii	For example: in reinforced concrete, the steel and the concrete must have the same thermal expansion. Otherwise, they will expand by different amounts and make the concrete crack.
	d		Infrared light has to travel through hundreds of kilometres through the fibre. Impurities would absorb too much of the light, so there would not be enough light energy for a signal.
	e		For example: • in a child's kaleidoscope, to make a pattern of reflections • in a microscope, to reflect light up onto the slide • to make an area inside a building look brighter and bigger
6	**a**		• The cable core is made of — copper — because it is a flexible conductor. • The plug pins are made of — brass — because it is a hard metal. • The socket case is made of — hard polymer — because it is a stiff insulator. • The cable insulation is made of — soft plastic — because it is a flexible insulator.
	b*		For example: • Reinforced concrete for bridges and buildings. The material must be strong in tension and compression to support the weight of the structure and the load. It must be tough because a sudden crack would be dangerous. • Glass-reinforced plastic for a canoe. The material must be light so it is easy to handle the canoe. It must be waterproof and hard, because it will get bumped a lot. It must be tough, because a sudden crack would be dangerous.
7	**a**		B, A, C
	b	**i**	10 000 Hz, 1000 Hz, 100 Hz, 10 Hz
		ii	2000 Hz
	c	**i**	Doubles
		ii	• pain — above 130 dB • normal conversation — 60 dB • temporary hearing loss — above 85 dB
	d	**i**	Bad temper, lack of sleep, poor concentration, permanent hearing loss, tinnitus

<table>
<tr><td></td><td></td><td>ii</td><td>
<table>
<tr><th>Structure</th><th>Material</th><th>Reflects or absorbs sound?</th></tr>
<tr><td>cavity walls</td><td>solid foam</td><td>absorbs</td></tr>
<tr><td>ceiling</td><td>acoustic tiles</td><td>absorbs</td></tr>
<tr><td>floor covering</td><td>underlay</td><td>absorbs</td></tr>
<tr><td>windows</td><td>double glazing</td><td>reflects</td></tr>
</table>
</td></tr>
<tr><td></td><td>e</td><td>i</td><td>Missing words: machine, vibrations, rigid, absorb, energy, wobble</td></tr>
<tr><td></td><td></td><td>ii</td><td>



Vibrations make the silicone oil move inside the damper. The fluid absorbs the energy of the vibrations. This can protect buildings from earthquake vibrations.</td></tr>
<tr><td></td><td>f*</td><td></td><td>Missing words: high, low, low</td></tr>
<tr><td></td><td>g</td><td></td><td>• opaque material — Light is absorbed inside the material.
• reflective material — Light bounces off the surface of the material.
• translucent material — Light can pass through the material, but we cannot see through it.
• transparent material — Light can pass through the material, and we can see through it.
• refraction — The change is speed of light as it enters a different material.</td></tr>
<tr><td></td><td>h*</td><td></td><td>Order from most refraction to least refraction: diamond, ruby, sodium chloride, Perspex, ice</td></tr>
<tr><td></td><td>i</td><td></td><td>• Infrared reflecting glass — reflects heat energy — e.g. double glazing
• lead glass — has a high refractive index — e.g. ornaments
• optical fibre glass — very transparent — e.g. transmitting signals
• photochromatic glass — goes darker in bright light — e.g. sunglasses
• tinted glass — slightly coloured — e.g. aesthetic purposes
• self-cleaning glass — keeps clean — e.g. windows in tower blocks
• toughened glass — does not shatter — e.g. low windows</td></tr>
<tr><td></td><td>j</td><td>i</td><td>(Top left) converging, (top right) diverging, (bottom left) converging, (bottom right) diverging</td></tr>
<tr><td></td><td></td><td>ii*</td><td>
</td></tr>
<tr><td></td><td>k</td><td></td><td>Missing words: focus, focal length, image, focal plane, power, high, low, dioptres</td></tr>
</table>

Further guidance

	l	**i**	• A real image made by a lens — can be seen on a screen. • A virtual image made by a lens — cannot be seen on a screen. • An inverted image made by a lens — is upside down compared with the object. • An upright image made by a lens — is the same way up as the object.
		ii	Labels clockwise from top right: shutter, lens, aperture, focal plane, viewfinder
	m		To transmit more light
	n*	**i**	• moves beyond the focal point • becomes larger
		ii	• a camera lens moves towards the object • becomes thicker
8	**a**	**i**	Missing words: alloy, dissolving, element, metal, solid soution
		ii	• hardness • tensile strength • corrosion resistance • melting point
	b	**i**	• Wood has — cellulose fibres — in a matrix of lignin • Reinforced concrete has — steel wires —in a matrix of concrete • Glass-reinforced plastic has — glass fibres — in a matrix of polymer
		ii	• Reinfoced concrete is used for buildings • Glass-reinforced plastic is used for the hulls of boats
	c*		For example: • A break cable, with steel wires inside a polymer coating. Their flexibility must be similar. • Clothing made of two (or more) fabrics. Their density, strength and flexibility must match.
	d*		For example: • gas permeable, to allow oxygen to reach the front surface of the eye • transparent, so you can see through them • easily sterilised, to avoid infections • stick to tears, so they stay in place
	e	**i**	Ceramics, composites, alloys, metals, polymers

ii

Class of material	First example	Second example
metal	iron	e.g. copper
alloy	duralumin	e.g. brass
polymer	polythene	e.g. PVC
ceramic	brick	e.g. glass
composite	beech	e.g. oak
composite	plywood	e.g. wood laminate
composite	glass-reinforced plastic	e.g. bone

iii

material property	metals	ceramics	polymers
stiff	✓	✓	✗
shiny	✓	✗	✗
brittle	✗	✓	✗
often flexible	✗	✗	✓
often plastic	✗	✗	✓
ductile	✓	✗	✗
malleable	✓	✗	✗
insulator of heat and electricity	✗	✓	✓
conductor of heat and electricity	✓	✗	✗

f **i**

- bridge — reinforced concrete — stiff and strong
- floor tile — ceramic — hard
- cooking pot — metal — high thermal conductance
- shopping bag — polymer — flexible
- spectacle lens — glass — transparent

ii

- A car window — hard, transparent
- The sole of a shoe — hard, flexible
- The wings of an aeroplane — light and strong
- The outer wall of a house — strong, hard, thermal insulator
- The central core of a mains cable — flexible, electrical conductor
- The outer casing of a mains cable — flexible, electrical insulator

Further guidance

	g		• aluminium • copper • mild steel
	h*	**i**	Missing words: concrete, steel wires, strong, weak, brittle, tension, tough
		ii	Missing words: glass fibres, matrix, plastic, brittle, strong, tough, weak