UNIT 1 Matter and Measurement

Recommended Prior Knowledge
Little prior knowledge is required here, although pupils will need to have encountered the idea of a graph and how, in physics, it is used to represent quantities and the relationships between them. Most of the other ideas are of the sort that many pupils will be familiar with at some level, although precise definitions may well be encountered here for the first time.

Context
This unit introduces pupils to the ideas of measurement and observation which are so fundamental to all aspects of physics. From the very beginning, pupils should be encouraged to be guided in their understanding of the subject by what has been measured and observed. Physics is not a question of opinion or education.

Outline
In this unit pupils should learn to make many of the simple, basic measurements which are vital to subsequent units. They should be able to distinguish between weight and mass and so realise that physics will sometimes make distinctions which are not important in ordinary life. Other quantities are also introduced or revised: density, speed/velocity, force, and moment of a force. The concept of a force field is covered and so are: proportionality, equilibrium, centre of mass and graphs. It should be emphasised, from this stage on, that numerical answers must include the appropriate unit.

	Learning Outcomes	**Suggested Teaching Activities**	**Online Resources**	**Other resources**
1(d)	Describe how to measure a variety of lengths with appropriate accuracy using tapes, rules, micrometers and, calipers using a vernier as necessary.	Pupils should use all the instruments in 1(d) regularly during the course. Calculate the volume of a wooden lath (~50 cm x ~10 cm x ~1 cm) and use the correct instrument for each dimension. Explain that accuracy comes from the measurements not the calculator. Use calipers with inside diameter, outside diameter and depth gauge facility.	Measuring: http://school.discovery.com/lessonplans/programs/lengths/ Using calipers: http://members.shaw.ca/ron.blond/Vern.APPLET/ Using a micrometer: http://www.upscale.utoronto.ca/PVB/Harrison/Micrometer/Micrometer.html	Make pupils familiar with SI units even in the normal course of their lives. Distances in km and so on.
1(e)	Describe how to measure a variety of time intervals using clocks and stopwatches.	Use a stopclock or stopwatch to time pendulums or oscillating weights or other pupils running upstairs or in races. Calculate speeds and work done and power expended.		

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1(f)	Recognise and use the conventions and symbols contained in 'Signs, Symbols and Systematics', Association for Science Education, 1995.	Wherever possible conduct the course with conventional symbols and SI units. Make pupils familiar with the more common prefixes: micro- (µ), milli- (m), kilo- (k), mega- (M).	SI Units: http://physics.nist.gov/cuu/Units/units.html	Emphasise that units follow the quantity; density is mass/volume and the unit of density is the mass unit/volume unit. Avoid negative index units, e.g. use m/s rather than ms^{-1}.
4(a)	State that mass is a measure of the amount of substance in a body.	Explain that in physics mass is different from weight. Pupils accept that as an object is moved around the Earth it is the same object, made of the same molecules in the same order and that something about it remains constant. This is the amount of matter or “stuff” it contains.	Mass: http://www.bbc.co.uk/schools/gcsebitesize/physics/forces/massandgravityrev1.shtml	This unchanging quantity is called the mass and is measured in kilograms. It is the quantity one is usually interested in when buying, say, fruit or vegetables.
4(b)	State that mass of a body resists change from its state of rest or motion.	Explain that mass determines how difficult it is to change the motion of a body (e.g. to speed it up); it determines the inertia of the body.		
4(c)	State that a gravitational field is a region in which a mass experiences a force due to gravitational attraction.	Pupils readily accept that as an object journeys around the Solar System, the force (unit 6) of attraction to the nearest planet changes with the planet’s proximity and mass. On Earth this force is approximately 10 N for every kilogram of the object’s mass. Emphasise that it varies according to height above sea-level (the actual value is between 9.79 N/kg and 9.83 N/kg). At this stage an appropriate “definition” of the Newton is “the weight of an average apple” – use a fruit or vegetable that the pupils will be most familiar with. The actual definition is encountered in unit 8.	Weight: http://en.wikipedia.org/wiki/Weight Gravity: http://csep10.phys.utk.edu/astr161/lect/history/newtongrav.html	
4(d)	Calculate the weight from the equation: *weight = mass x gravitational field strength.*	Calculate pupils’ weights. For other planets or on the Moon, use values other than 10 N/kg.		

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4(e)	Explain that weights, and therefore masses, may be compared using a balance.	Emphasise that lever-arm balances compare unknown weights/forces with the weight of a known mass. This is equivalent to comparing masses since $W = mg$. Would such a balance be accurate on the Moon?	Lever-arm balances: http://edinfo.securesites.net/math_science/mass_weight.htm	
4(f)	Describe how to measure mass and weight by using appropriate balances.	Spring balances measure the weight and deduce the mass assuming that g = 10 N/kg. Is this a valid assumption on the Moon?		
4(g)	Describe how to use a measuring cylinder to measure the volume of a liquid or solid.	Pupils will learn how to do this most readily by actually doing it. Get pupils to measure the volume, mass and density of common liquids such as cooking oil, orange juice etc. Use the bottom of the meniscus for such liquids (this is the top of most of the liquid). Measure the volume of bolts and pebbles and coins (use more than one if the volume is small) by immersing in water. Does immersion in oil give a different value?	Measuring cylinders: http://www.saburchill.com/chemistry/chapters/chap0021.html	
4(h)	Describe how to determine the density of a liquid, of a regularly shaped solid and of an irregularly shaped solid which sinks in water (volume by displacement).	Emphasise that volume and mass are properties of an object. They vary from object to object even when they are of the same material. Density, however, is a property of the material from which the substance is made.	Density: http://www.nyu.edu/pages/mathmol/modules/water/density_intro.html	
4(i)	Make calculations using the formula *density = mass/volume.*	Calculate the volume of wooden blocks, metal bars, and glass prisms.		

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2(a)	State what is meant by speed and velocity.	Pupils are probably familiar with these ideas from ordinary situations, but emphasise that what they already know can be put into equation form: $v = d/t$ and that the unit of speed follows from the equation: km/h or m/s. Explain that in physics it is important to separate speed and velocity. Speed ignores the direction travelled but the formal distinction between scalar and vector quantities can wait.	Speed and velocity: http://www.glenbrook.k12.il.us/gbssci/phys/Class/1DKin/U1L1d.html	
2(b)	Calculate average speed using distance travelled/time taken.			
6(a)	State that a force may produce a change in size and shape of a body.	Allow pupils to contribute as many words as possible here: • twist, • stretch, • compress, • shrink, • distort, • contort, • expand • etc. Let pupils suggest their own examples: car crashes, foam rubber, motorcycle crash helmets.	Change in shape/size: http://www.factmonster.com/ce6/sci/A0819139.html or: http://www.bbc.co.uk/schools/ks3bitesize/science/physics/forces1_1.shtml	
6(b)	Plot, draw and interpret extension-load graphs for an elastic solid and describe the associated experimental procedure.	These experiments can be performed by the pupils themselves. Stretch springs, rubber bands and strips of polythene – glue a piece of wood to the bottom of the strip and attach the weights to it. Use springs in parallel and in series. Compare the gradients of the extension-load graphs.	Hooke's law: http://www.darvill.clara.net/enforcemot/springs.htm	

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6(c)	Recognise the significance of the term "limit of proportionality" for an elastic solid.	At this level the limit of proportionality and the elastic limit can be assumed to be the same.	Elastic limit: http://www.ac.wwu.edu/~vawter/PhysicsNet/Topics/SHM/HookesLaw.html	
6(d)	Calculate extensions for an elastic solid using proportionality.	Use $T = kx$ or $mg = kx$. Use these equations to explain proportionality. Also use more domestic examples: the price of fruit α the amount purchased, wages earned α hours worked. In both cases, there can be different constants of proportionality.	Proportionality: http://www.themathpage.com/ARITH/proportionality.htm	
5(a)	Describe the moment of a force in terms of its turning effect and relate this to everyday examples.	Pupils are likely to be familiar with children of unequal weights balancing on see-saws. Ask how it is done. Use a metre rule and some small masses balanced on a knife edge to verify the principle of moments. Then use it to determine the unknown mass of a small can. Work up through larger objects and measure the mass of a pupil balancing on a plank. Measure the mass of the rule by placing a weight at one end and balancing the whole arrangement at a point between the weight and the rule's centre of mass.	Moments: http://www.explorelearning.com/index.cfm?method=cResource.dspDetail&ResourceID=41 or: http://www.walter-fendt.de/ph14e/lever.htm	Use traditional weighing machines and balances and the steelyard, the chemical balance and so on. Use examples with which the pupils are likely to be familiar.
5(d)	Describe how to verify the principle of moments.			
5(b)	State the principle of moments for a body in equilibrium.	State the principle using weight not mass: $m_1gx_1 = m_2gx_2$		
5(c)	Make calculations using *moment of a force = force x perpendicular distance from the pivot* and the principle of moments.	Use the principle of moments to define the *moment of a force* and emphasise it measures the turning effect of a force. Consider everyday examples: • spanners, • wrenches, • opening tins with screwdrivers and spoons,	Torque (moment): http://hyperphysics.phy-astr.gsu.edu/hbase/torq.html	

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		• the steering-wheel, • door handles, • taps, • etc.		
5(f)	Describe qualitatively the effect of the position of the centre of mass on the stability of simple objects.	Emphasise that the centre of mass is a single point through which the entire weight of an object can be taken to act. Use a board whose gradient can be changed to investigate the stability of rectilinear blocks of wood (short and wide or tall and thin), use cones and inverted cones (sawn off to balance), use stemmed glasses and thick bottomed glasses (empty and containing water).	Centre of mass: http://www.qwerty.co.za/puzzles/mass/cofmcoke.htm or: http://www.phy.ntnu.edu.tw/java/block/block.html	Consider the effect of heavy chassis on the stability of buses or the results of heavy loads on the roofs of narrow minibuses.
5(e)	Describe how to determine the position of the centre of mass of a plane lamina.	Use a variety of thick card or thin wood laminas: triangles, squares, rectangles, pentagons, star shapes, L-shapes, O-shapes, rings and squares with square holes.	Centres of gravity of laminas: http://www.mathematische-basteleien.de/geocentre.htm	Cut out a map of the country printed on to thick card. Find the centre of gravity. Is this accurate?