WRITE ON THIS PAPER UNLESS TOLD OTHERWISE. **CLEARLY SHOW ALL WORKINGS!** PAY ATTENTION TO NEATNESS AND ORGANIZATION. HAND IT IN ON TIME. HAVE A GO EVEN IF AT FIRST YOU CAN'T SPOT THE ANSWER!

NAME: ..... SET: ..... DATE: .....

Measurement/Density/Units

Question 1

A meteorite is placed in a cylinder of water. The radius of the cylinder is 5cm. When immersed the height of the water rises by 2cm. Meteorites are known to have densities between 3 and 8 g/cm^3. Calculate the range of masses you expect the meteorite to have.

Question 2

Samples of a rare meteorite can be bought for £500 per gram. A ring is to be fashioned. The inner radius is 6mm, the ring thickness is 2mm and the height of the ring is 5mm. If the density is 7g/cm^3, calculate (i) the mass of the ring and (ii) the cost of materials

Question 3

An electrical signal is to be transmitted along a 100km cable between Winchester and London. The signal travels at one fifth of the speed of light in a vacuum, which is $c = 2.998 \times 10^8 \text{ms}^{-1}$. Calculate the travel time in micro-seconds (μs)

Question 4

1 inch = 2.54cm, 1 month = 365/12 days

A nerve can re-grow at a rate of about 1 inch per month. Calculate this speed in ms^{-1}, writing your answer in standard form to 2.s.f.

Question 5

According to a report in 2017, the European Union wastes about 88 million tonnes of food a year. If the average density of food products is 25% higher than water, and water has a density of 1000kg/m^3, calculate the volume of food wasted.

Please express your answer in terms of number of filled swimming pools. (Dimensions are 25m x 10m x 2m).

Question 6

1 electron-volt (eV) is about $1.602 \times 10^{-19} \text{J}$. An alpha particle of mass $6.64 \times 10^{-27} \text{kg}$ is accelerated to 10% of the speed of light. Calculate its *kinetic energy* in electron-volts. Note the speed of light is $c = 2.998 \times 10^{8} \text{ms}^{-1}$.

Question 7

A lake of uniform depth of 10m evaporates at a rate of 200mm per year. If no water enters the lake via rainfall or rivers, calculate how long (in years) it will take for the lake to become dry.

Question 8

On average, a person in the UK requires about 0.72 billion joules of energy every day to live a comfortable modern life. The UK population (in 2017) is about 65 million. If a nuclear power station has a generating capacity of 2GW (i.e. 2×10^{9} joules per second), calculate the number of nuclear power stations the UK needs, if all of its energy needs are supplied in this way. (Note the UK has just fifteen active reactors as of 2017).

Kinematics

Question 1

(i) What is 70mph in metres per second? (1 mile = 1,609m)

(ii) A car breaks with a uniform acceleration of '0.5g' i.e. about $5ms^{-2}$. Draw a *velocity vs time* graph to describe the breaking of a car from 70mph. Hence work out (a) the time it takes to stop and (ii) how far it has travelled since the breaks were applied.

Question 2

Charlie and Craig decide to walk 500 miles, and then 500 more. Excluding any stops, they build up (at a constant rate) from zero to 20 miles per day over 20 days. They carry on until they have 100 miles left. At this point they slow at a constant rate until they reach their thousand mile target.

Sketch a speed (miles per day) vs time (days) graph, and hence work out how long it takes them.

Moments

Question 1

An enormous vegetable (mass 10kg) is to be uprooted with a spade. When the spade is underneath the vegetable, the distance to the pivot point (the top of the spade) is 15cm. A gardener exerts a force at a distance of 80cm from the pivot point. Calculate, in Newtons, what this force needs to be to raise the vegetable. Ignore the weight of soil, and take $g = 9.81\text{ms}^{-2}$.

By way of a diagram explain how the distances stated relate to the vegetable, the gardener and the spade.

Question 2

A man takes his three children to the park and they all have a go on a see saw. Anne (30kg) sits 40cm from the fulcrum, Bella (40kg) sits 1m from the fulcrum and Charles (25kg) sits 1.5m from the fulcrum. If the man has a mass of 80kg, calculate how far he must sit from the fulcrum on the opposite side to maintain equilibrium.

Uncle Pete (75kg) now sits 20cm behind his brother, and Auntie Maud sits where Charles sat, and sits him on her lap. How heavy is Auntie Maud?

Work/Weight/Energy Assume $g = 9.81\text{ms}^{=2}$ unless otherwise stated.

Question 1

Pen-y-Pass Youth Hostel is at an altitude of 359m. The peak of Snowdon is 1,085m. Calculate the work done against gravity if a 72kg man makes the climb. If it takes him two hours, what is the average power expended?

Two oatibix biscuits contain 798kJ of energy. How many ascents of Snowdon correspond to one oatibix?

Question 2

A piano falls 30m from a high rise building. Ignoring the effect of air resistance, calculate the velocity of impact.

Question 3

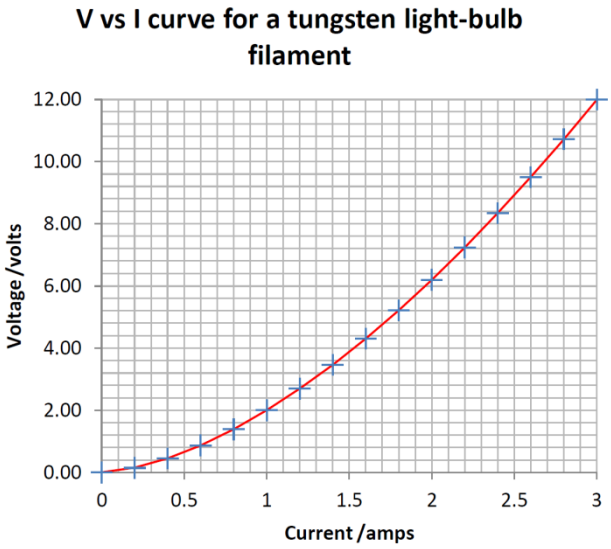
Jim the astronaut has a vertical leap of 50cm on Earth. Calculate his launch velocity.

Assuming a similar launch velocity on the surface of Mars, calculate Jim's leap height. Note $g_{\text{Mars}} = 3.8\text{ms}^{-2}$

Electricity & Circuits

Question 1

(i) Draw a circuit that could be used to generate the current (I) vs voltage (V) curve below



(ii) Use the graph to calculate the resistance at (a) V = 2volts

and (b) V = 10volts.

(iii) Explain in terms of atoms and electrons, the results in part (ii)

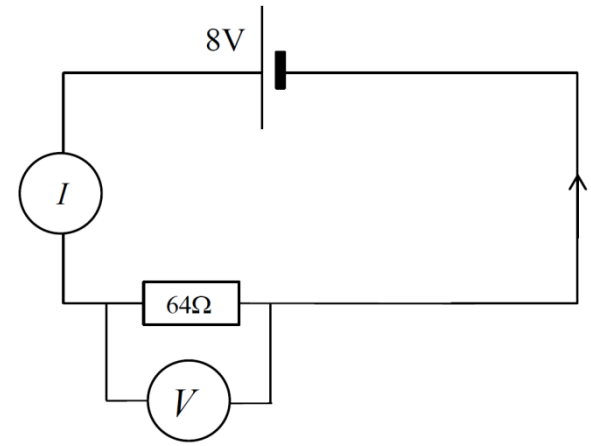
Question 2

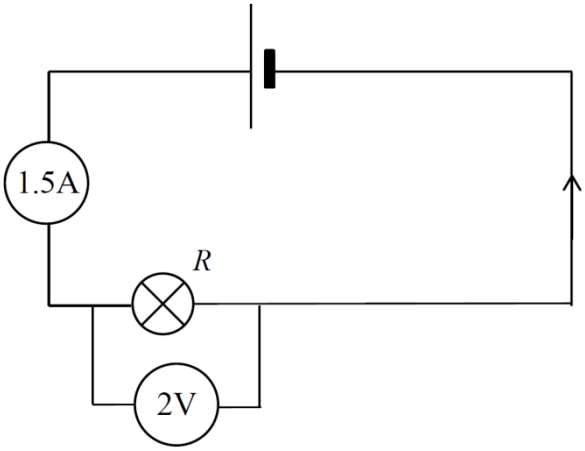
(a) How much energy is drawn from a 6V battery, if 10 coulombs of charge are transferred? Assume the battery voltage remains constant.

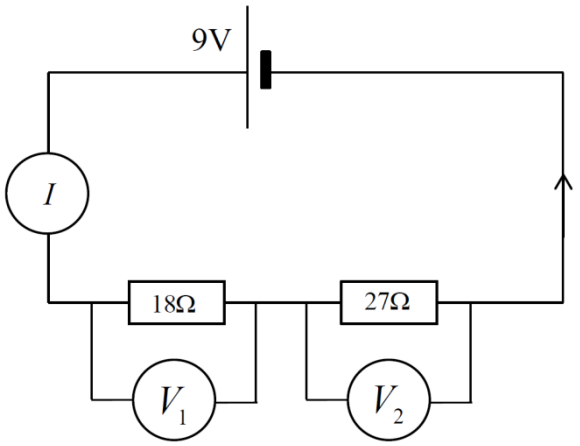
(b) A total of 1000J is extracted from a 12V power supply in 5 minutes. Calculate the average current, in amps.

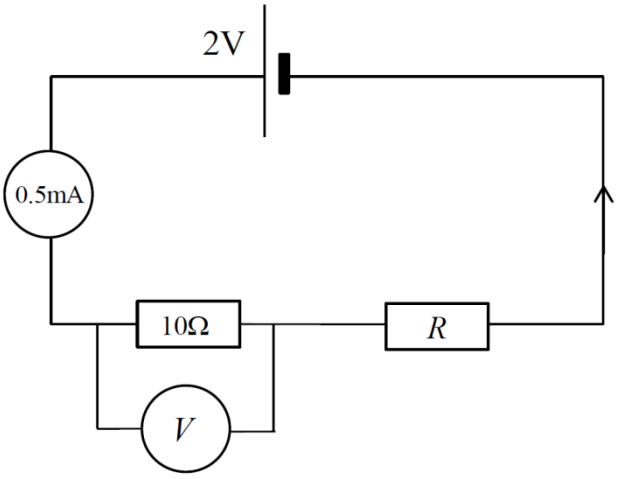
Question 3

Find the unknown currents, voltages and resistances in each circuit



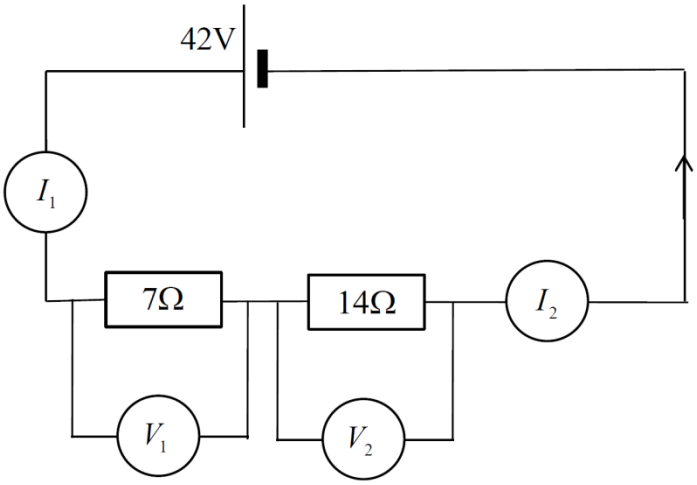


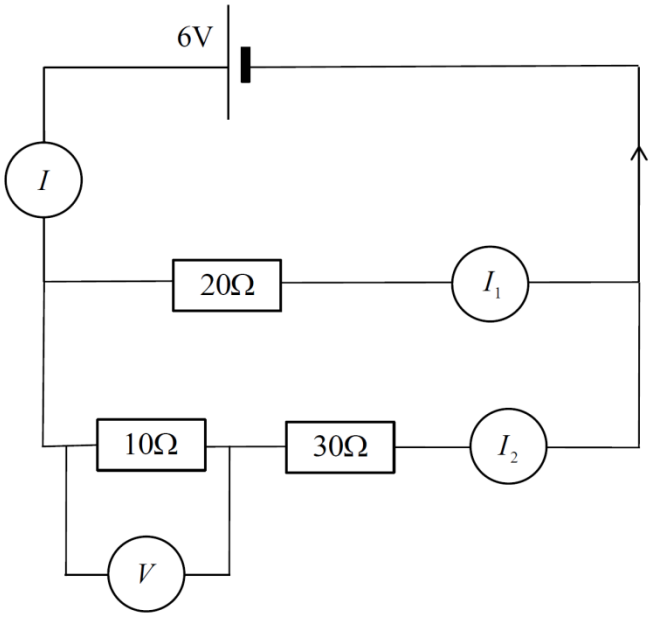


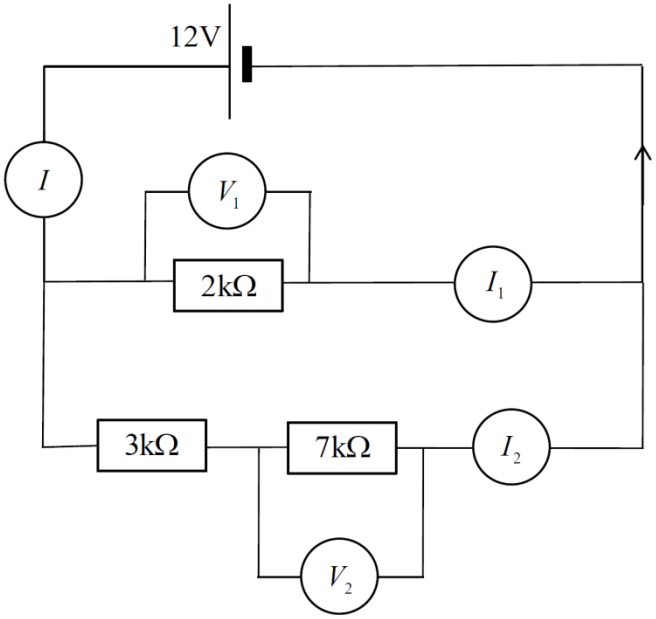


Question 4

Find the unknown currents, voltages in each circuit







Springs

Question 1

An athlete uses a spring as part of a fitness regime. She expends 100J stretching the spring 20cm. Calculate the spring constant (i.e. the stiffness, in N/m).

Hence calculate the maximum force applied to stretch the spring.

Question 2

A boy (mass 55kg) piles two pocket-sprung mattresses on top of one another during a boarding house spring clean. He leaps on top and moves downward by 5cm. Assume each mattress is a grid of single identical springs, and 30 springs cover the surface area of the boy on each layer.

Calculate the spring constant for each spring.

Magnetism

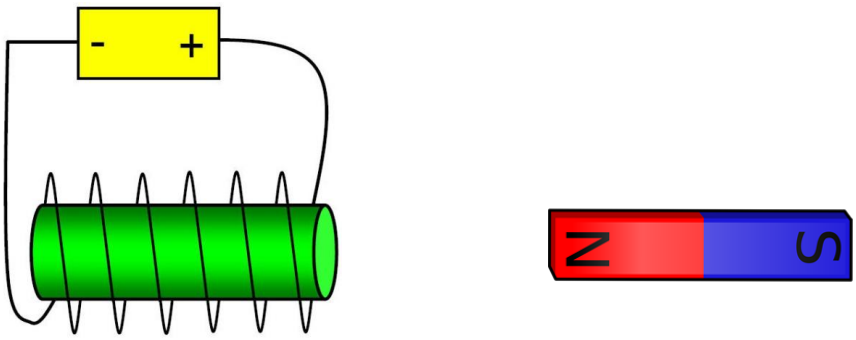
Question 1

Explain why a *soft* magnetic material like iron is often coiled with current carrying wire to make an *electromagnet*, rather than a *hard* magnetic material like steel.

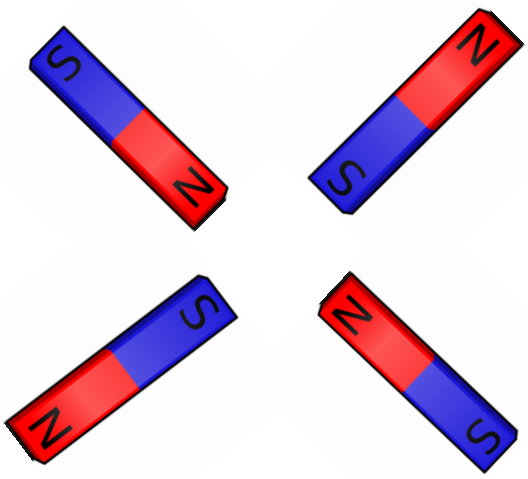
Question 2

Sketch the magnetic field lines around the following magnetic objects

(i)



(ii)



Forces & acceleration

Question 1

A cross-country runner of mass 70kg tries to run through a muddy bog. The resistance of the bog is one half of his weight.

(a) Draw a force diagram to represent the situation, and write down Newton's Second law in terms of quantities you define.

(b) Calculate the force the runner must exert in the direction of motion if his acceleration is 0.1ms^{-2}

Question 2

Three forces act on a robot dog of mass 11kg.

$$\mathbf{f}_1 = \begin{pmatrix} 2 \\ -3 \end{pmatrix}, \quad \mathbf{f}_2 = \begin{pmatrix} -2 \\ 0 \end{pmatrix}, \quad \mathbf{f}_3 = \begin{pmatrix} -3 \\ -1 \end{pmatrix}$$

Find the *resultant* force vector, and hence work out the magnitude of the acceleration of the dog.

Draw a vector diagram to show the result above. (Draw a free body diagram, *and* also add the vectors tip to tail).

Light & Sound waves

Question 1

In order to listen to BBC Radio 4, an analogue radio must be tuned to somewhere in between 92MHz and 95MHz.

If the speed of light is $c = 2.998 \times 10^8 \text{ms}^{-1}$, calculate the range of wavelengths (in metres) this corresponds to.

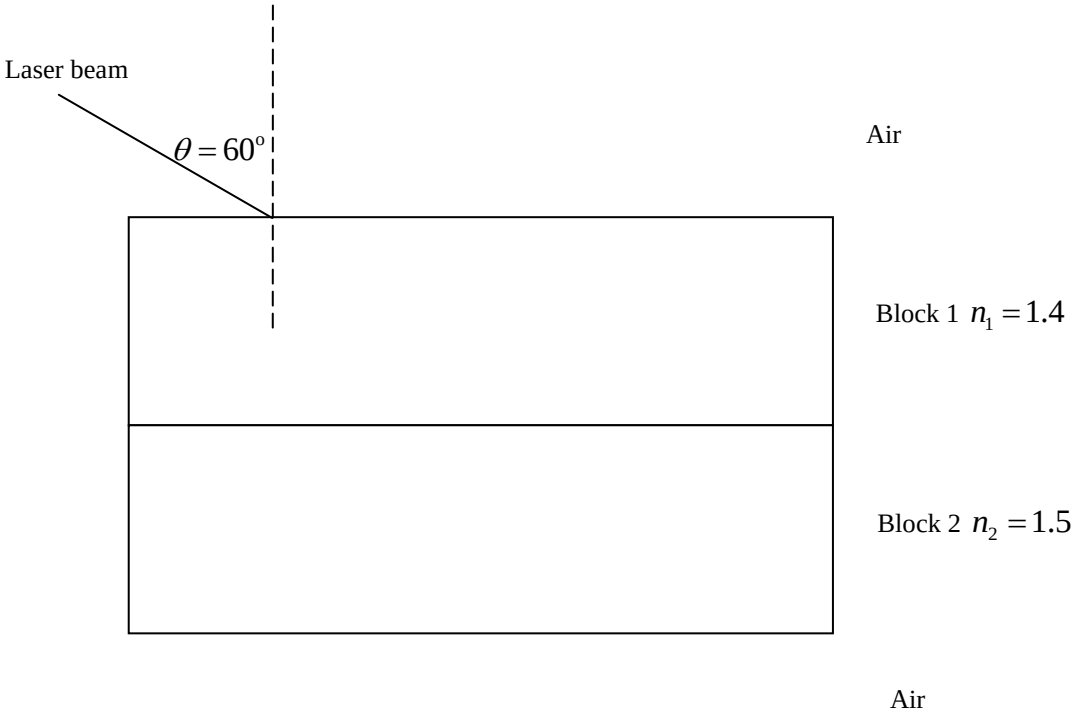
Question 2

A laser beam is fired from air into a rectangular block of refractive index $n_1 = 1.4$. The beam continues through the block and then enters another one, with refractive index $n_2 = 1.5$. It then exits this block into air.

Use **Snell's law** to calculate the angles of **refraction** for (i) air to block 1; (ii) block1 to block2 and (iii) block2 to air.

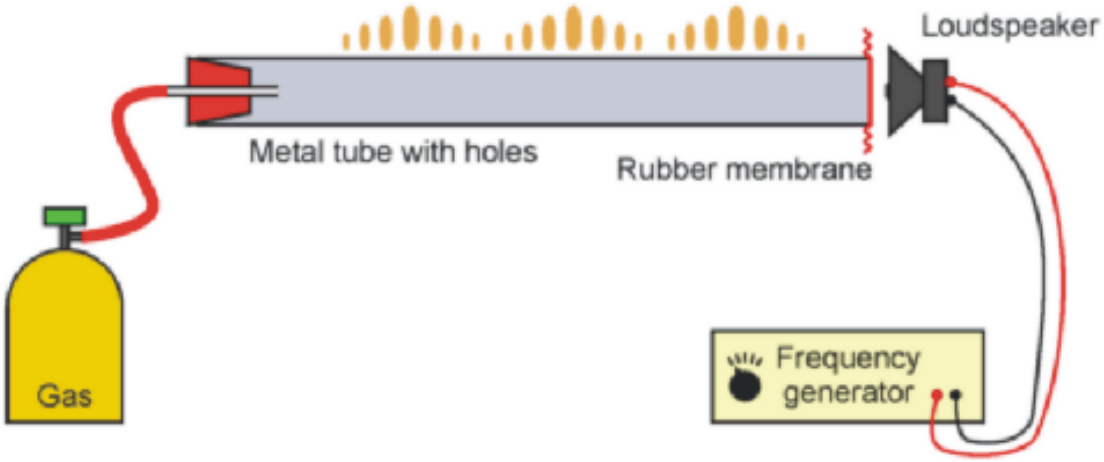
Use this information, and a **pencil, ruler and protractor**, to carefully draw the path of the laser beam using the diagram below.

Don't forget to include reflections as well.



Question 3

A Rubens Tube is described below. Use vertical lines to indicate the positions of compressions and rarefactions of the gas in the tube. (Tightly spaced lines mean a compression).



Question 4

Using water waves as an example, draw three sketches (with wave-front lines, and arrows) to represent *reflection*, *refraction* and *diffraction*.

Power & electromagnetism

Question 1

Using appropriate diagrams, explain how to make a **loudspeaker** out of card, wire, sticky tape, magnets and an amplified signal from an mp3 player.

Explain using ideas of **electromagnetism**, *why* the speaker cone can be made to move in time with the electrical signal.

Explain briefly how the design could be modified to generate louder sounds, *without* changing the current in the wires.