Getting Ready for...

KS5 (A Level) Physics

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Activities

When doing A level Physics it is important to be able to think ideas through and try to develop good explanations. These questions are designed to get you thinking. Have a go at them and be prepared to do a bit of research to develop your responses.

Many of the ideas here are ones you will have met while doing GCSE Physics or the Physics part of Combined Science, but are in a new context. Others may be completely new to you. Don't worry if you can't recall an answer straight away, but see what you can work out.

1. Refraction

A ruler is put into a jug of water. This is what it looks like from the side. As you can see, it looks as if the ruler is broken where it passes through the surface of the water.

If we look closely at where the ruler goes through the surface of the water, it looks like this. You can try this out quite easily by putting your own ruler or pencil into a glass of water.

a. See if you can explain why this happens, using ideas about the refraction of light.

b. Draw a diagram to show what you think is happening to light rays travelling from the ruler to your eye. Draw the diagram as if you were looking down on the jug from above. The diagram should show (using continuous lines) the path that light actually takes. It should also show (using broken lines) where the eye (and brain) thinks the light is coming from.

The ruler is now turned so we can see the front of it. It is still in the jug and partly submerged.

We can look in more detail at where the ruler enters the water.

c. Describe the effect you can see.

d. Suggest whether this could be referred to as an optical illusion.

e. In fact, the jug is acting as a lens. See if you can draw a diagram to show the path taken by light travelling from the ruler to your eye. A good way of doing this is to draw it as viewed from above. Your diagram should show how the light actually travels and also how your eye thinks the light has travelled.

2. Radioactive decay

Radium is a naturally radioactive material. As time goes by it decays to form radon. Each atom of radium splits into an atom of radon and an alpha particle.

a. What does an alpha particle consist of?

b. Why is an alpha particle also referred to as a Helium nucleus?

c. If we represent the decay using this equation: ${}^{226}_{88}Ra \rightarrow Rn + {}^{4}_{2}He$ (radium is Ra and radon is Rn), see if you can work out the mass number and the atomic number of radon.

d. We can model radioactive decay by having a tray of, say, 100 dice. The dice are shaken and all those showing a six are removed and counted. The remaining dice are shaken and the process repeated until all the dice are gone. The number of sixes each time gradually becomes less and less.

 i. How is this a good representation of radioactive decay?

 ii. In which ways is it not a good model?

3. Motion and energy

Maya is six years old and loves riding on a swing in the playground. Her mother pushes her to get her started and then lets her swing to and fro. Each oscillation is the journey from the furthest point back to the furthest point forwards and then back again.

a. What is the difference between speed and velocity?

b. Describe how her speed varies during one complete oscillation.

c. Now describe her journey in terms of acceleration. Clearly identify where she is accelerating and whether this acceleration is positive or negative.

d. When Maya's mother pulls her back at the start of the ride she is transferring energy to Maya. When she lets go, the gravitational potential energy stored in Maya is transferred to kinetic energy. Explain how the amounts of these alter during one complete oscillation.

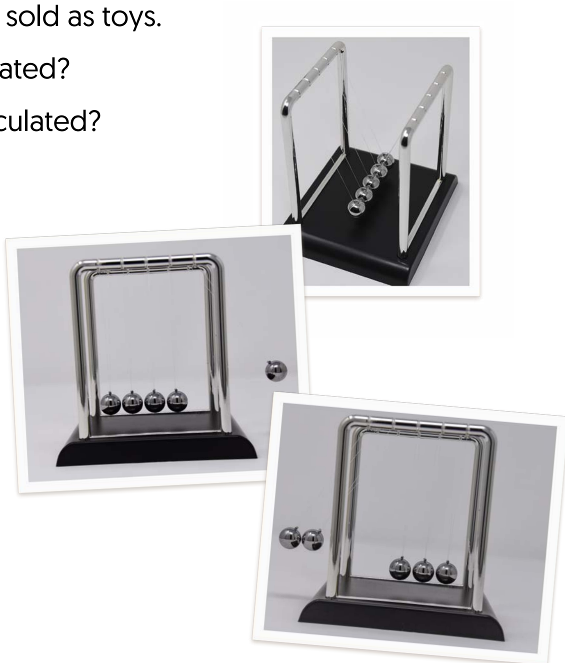
e. After a while, Maya comes to rest. Where has the energy gone?

4. More on motion and energy

A Newton's Cradle typically consists of five metal balls, each suspended by two fine wires from a frame. They are often sold as toys.

a. How is momentum calculated?

b. How is kinetic energy calculated?



The ball at the left is pulled back and released. When it hits the other balls, the one at the right flies up and then swings back. This goes on for several minutes.

If two balls are pulled back on the left and released, when they hit the other balls, two on the right fly off and land back, and so on.

c. Explain how this demonstrates both conservation of momentum and conservation of kinetic energy.

d. Paul sees this and says "I don't understand why setting one ball in motion at one end always causes just one ball to fly off at the other end. If momentum is conserved then surely you could have two balls moving off at the other end but at half the speed – that would conserve momentum." How would you respond to this?

5. Voltage and current

Stella sets up a circuit to investigate the voltage-current characteristics of a light bulb. She knows she has to connect the voltmeter and the ammeter correctly for them to work and produce data.

a. Explain how to put the voltmeter in the circuit and how to include the ammeter. Use the terms 'series' and 'parallel' in your explanation and sketch the arrangement.

b. Including the meters should, ideally, not alter the way the circuit behaves. Explain, therefore, what you would expect to be true about:

   i. The resistance of a voltmeter.

   ii. The resistance of an ammeter.

c. You have been asked to mentor a student in Year 9 who is starting their GCSE course and has done some work with circuits. They say "I don't understand why we measure both voltage and current. If one goes up, so does the other. They're just ways of measuring how much electricity is flowing – they're the same thing really." How would you respond and explain the difference?

6. Standard prefixes

Measurement and the use of units are key parts of Physics. This activity involves thinking about measuring distance and the use of the metre as a unit.

a. Draw a table with three columns and 31 rows. Head the columns like this:

Factor	Prefix	Example (reference to distance in meters)

b. Now enter values in the first column going from 1015 going down to 10-15. This is why you need 31 rows.

c. Some of these factors have standard prefixes. These are ones in which the index is a multiple of three. For example, 103 has the prefix of kilo and 106 is mega. Research the other standard prefixes and enter these in the second column.

d. These factors and prefixes apply to all units, but in the third column we are going to apply them to distance and the use of metres. Below is a list of objects that you are going to use as examples. For instance, if you think that the nearest one of those measurements to the diameter of a large city was 104 metres, then you would enter that in the third column next to that factor.

    i. Use your skill and judgment to enter the following examples into the table. Remember that we are approximating to the nearest available value.

    - Diameter of a large city, e.g. London
    - Diameter of outer electron shell of carbon
    - Diameter of a white blood cell
    - Diameter of a proton
    - Distance Earth travels in one hour
    - Width of a strand of DNA
    - Diameter of Moon's orbit around Earth
    - Nucleus of carbon atom
    - Diameter of Solar System

    ii. Now research the right answers.

7. Earthing

Plasma globes are sold in high street stores as novelty items. At the centre of the globe is a high voltage electrode and the transparent globe is filled with inert gases such as neon. When switched on, filaments of plasma flow extend from the central electrode to the outer globe.

a. Suggest why it is necessary for the central electrode to be at a high voltage.

b. Explain why even though this electrode will be at a voltage of several kilovolts, it is not dangerous.

c. If someone touches the globe with their finger, then the filaments flow towards it. Suggest why this happens.

d. Electrical appliances with a metal case have to be earthed to make them safe.

   i. Explain what earthing is.

   ii. Explain why it is only used with metal appliances.

   iii. Explain why touching a plasma ball demonstrates the principle of earthing.

8. Moments

Maya is in the playground with her father and her younger sister, Anna. Anna wants to ride on the seesaw and is very keen for all three of them to go on at once.

a. How is the moment of a force calculated?

b. The father knows he is heavier than his daughters and that they need to balance the seesaw. Explain how he can use the idea of moments to estimate where he should sit and where the girls should be to balance the seesaw.

c. Anna announces that she wants to be on her own on one side of the seesaw and that her sister and father have to be on the other side. Anna is the lightest; explain whether it is possible for her to balance the other two.

9. Circular orbits

Communications satellites are sometimes put into geostationary orbit. This means that they are orbiting the Earth at the same rate and in the same direction that the Earth is rotating.

a. Why is this useful when setting up communications links between, for example, the UK and the US?

b. Draw and label a diagram to help explain to someone why even though the satellite is in orbit, it always seems to be in the same place relative to an observer on Earth.

c. Some other satellites, such as those used to gather images for weather forecasting, are often put into a lower orbit.

  i. Suggest why they might need to be nearer to the Earth.

  ii. Suggest the implications of being in a lower orbit for the speed they need to orbit at.

10. Energy

An experiment is set up with two small black slabs, each one around 10cm x 10cm x 1cm. The slabs are the same colour; one is made of metal and the other plastic. On each slab are put three ice cubes.

The two slabs are left next to each other for a minute, after which the experiment looks like this.

On the left hand slab the cubes are visibly smaller; they have partially melted and water is standing on the slab.

a. Suggest which of these slabs is the metal one and which is the plastic one.

b. Suggest why the ice has melted much more rapidly on one than the other.

c. Explain this process in terms of energy transfer.