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KNOX GRAMMAR SCHOOL

STATE

DA VINCI DECATHLON 2021

CELEBRATING THE ACADEMIC GIFTS OF STUDENTS

IN YEARS 5 & 6

SCIENCE

TEAM NUMBER ______________

1	2	3	Total	Rank
/9	/31	/10	/50	

SECTION 1 – KNOWLEDGE AND UNDERSTANDING

THE UNCERTAINTY PRINCIPLE

The term “***uncertainty principle***” suggests some grand philosophical idea, like “you can never be sure of anything”, or “there are some things you can never be sure of” and sometimes people use it as if this is what is meant.

Werner Karl Heisenberg (1901 - 1976)

In fact, this principle proposed by German theoretical physicist Werner Heisenberg in 1927 is typically relevant only to microscopic particles.

In science we are ultimately concerned with what we observe. So when we say we are uncertain about something, we mean that we are uncertain about what we will observe when we do an experiment.

The simplest example of the uncertainty principle is the following: You can never be certain of both the position and the speed of a microscopic particle. It is possible to arrange an experiment so you can predict the position of a particle. A different experiment would let you predict its speed. But you will never be able to arrange things so that you can be certain of both its position and its speed.

Of course, life would be pretty boring if we could always predict what was going to happen next, but for many centuries, scientists dreamt they would be able to do this.

In the eighteenth century, a physicist called Pierre-Simon Laplace proposed the idea that we could use mathematics to determine all future events. We call his ideas ***physical determinism***. Laplace said,

"We may regard the present state of the universe as the effect of its past and the cause of its future. An intellect which at a certain moment would know all forces that set nature in motion, and all positions of all items of which nature is composed, (and) submit these data to analysis, (could predict) the movements of the greatest bodies of the universe and those of the tiniest atom; … nothing would be uncertain and the future just like the past would be present before (our) eyes."

Laplace believed that real chance did not exist. For Laplace, the random outcomes were not predictable only because we lack the detailed information to predict. Laplace explained the appearance of chance as the result of human ignorance. He said as early as 1783, "The word 'chance,' expresses only our ignorance of the causes of the phenomena that we observe to occur."

So what are the limitations of Science to predict the chance of something occurring? We use Science all the time to reliably predict the movement of objects and the strength of structures and yet through scientific investigation we have discovered that there will always be a measure of uncertainty. It was only in the examination of the movement of the smallest things we know of by Heisenberg and his colleagues that we began to realise it.

QUESTION 1

The uncertainty principle is an important idea in **quantum physics** because when things are very, very small, a tiny degree of imprecision makes a big difference. In **classical physics,** which we use most often to explain the movement of larger objects, tiny degrees of uncertainty don't affect our observations enough to be particularly noticeable.

1. Use **classical physics** to calculate how long a tennis ball would take to land in a friend's hands who was standing 10 metres away if you threw it at 20metres per second. Write a sum that shows how the time would be calculated. **(2 MARKS)**

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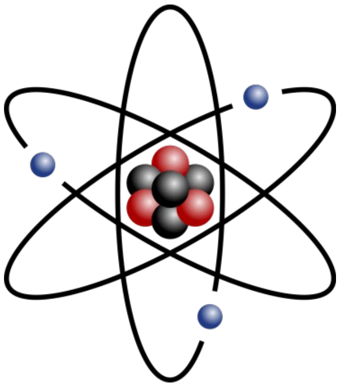
2. **Quantum physics** is particularly useful in explaining the behaviour of sub atomic particles. A *sub* (below) *atomic* (an atom) particle is something that is smaller than an atom. List the sub atomic particles shown in this diagram and identify the electrical charges of each. **(3 MARKS)**



   a. ____

   b. ____

   c. ____

3. This uncertainty principle applies to everyday-size objects, but is not noticeable because the lack of precision is extraordinarily tiny. If a baseball's speed is known to within a precision of 0.15km/h, the maximum precision to which it is possible to know the ball's position is 0.0000000000000000000000000000008 millimetres.

   We use scientific notation to write 0.0005 as $5x10^{-4}$ and 0.00006 as $6x10^{-5}$

   Write 0.0000000000000000000000000000008 millimetres using scientific Notation **(1 MARKS)**

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QUESTION 2

The three scientists shown below explored chance and uncertainty. Match the statements to the scientist most likely to express them by joining the photograph to the statement with a line. **(3 MARKS)**

Erwin Schrödinger

The future of everything in the universe is entirely predictable if we can know its current state.

Werner Heisenberg

If I put a cat in a box with a bottle of poison and a hammer that will break the bottle if a radioactive material begins to decay, it is impossible for the cat to be both alive and dead when the box is closed.

Pierre Laplace

You can never be certain of both the position and the speed of a microscopic particle. If you precisely calculate the speed, you cannot be precise about the position. If you calculate the exact position, you cannot also be precise about the speed.

SECTION 2 – EXPERIMENTAL DESIGN

DROPPING MY TOAST

Have you ever heard someone claim that if you drop your piece of toast at breakfast time, the chance of it landing marmalade/vegemite/peanut butter side down is 100%? The Institute of Physics (physics.org) claims that the side that hits the floor is indeed ***not*** random chance.

They claim it all depends on how you dropped it, from where you dropped it and how big your slice of toast actually is. All of these factors contribute to the butter side up or butter side down landing position.

In our typical early morning scenario, the toast slips off the side of the table and is given a slight rotation as it starts to fall. As most kitchen tables and work surfaces are about waist height, the toast only manages half a rotation before it hits the floor, butter side down. So, if you want to have your toast landing butter side up, you'd better build your work surfaces twice as high or make smaller slices so that they have time to complete the rotation.

QUESTION 1

What three factors do the Institute of Physics claim will reduce the frequency with which the side with a sticky spread on it hits the floor? **(3 MARKS)**

1. ______________________________
2. ______________________________
3. ______________________________

QUESTION 2

Choose just one of the factors listed above and design a scientific investigation to investigate how it changes the chance of having your toast land on the floor spread side down.

Aim: **(2 MARKS)**

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Independent Variable (what you make different to examine its effect)**:** **(2 MARKS)**

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Dependent Variable (what you measure to calculate that effect)**:** **(2 MARKS)**

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Controlled Variables (things you must keep the same to make it a fair test)**:** **(4 MARKS)**

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Hypothesis (What you predict to show in your measurements/data)**:** **(3 MARKS)**

Diagram of Setup: **(4 MARKS)**

Procedure: **(7 MARKS)**

How will the reliability of the investigation be optimised? **(2 MARKS)**

How will the validity of the investigation be ensured? **(2 MARKS)**

SECTION 3 – EXTRACTING AND ANALYSING DATA

THE CHANCE OF DEATH

In the following article published on The Conversation website (https://theconversation.com/whats-most-likely-to-kill-you-measuring-how-deadly-our-daily-activities-are-72505), Senior Lecturer in epidemiology at La Trobe University explains how scientists calculate and compare the risk posed by different activities.

It's always distressing and tragic when we hear a report of shark attack. But what is the actual likelihood of dying due to a shark encounter in Australia? How concerned about this are you as you go swimming? How concerned should you be?

So let's answer the first question: how likely is a fatal shark attack for an Australian? To get a crude estimate of this, averaged across the whole population, you would divide the number of people who have died due to a shark attack each year (on average three to four each year based on recent data) by the population of Australia (approximately 24 million). This yields a risk of approximately one in eight million per year, which is thankfully very low.

Does this assuage your fear? If not, the reason is probably that the imagery of a shark attack is so terrifying. Any unusual and dramatic event has a huge impact on our psyche and this distorts our perception.

Also, it's not that easy for us to interpret what a risk expressed as a relative frequency truly means.

Putting risks into perspective

So how can we tackle this issue of understanding risk better, and putting it into perspective? One interesting and useful way is to use the "micromort" – a one-in-a-million chance of death – as a unit of risk to help with comparisons between risky events. A Stanford professor first suggested this tool in the 1970s.

If something exposes you to a micromort of risk, this means it exposes you to a one-in-a-million chance of dying. Using micromorts to understand risk is by no means perfect, but it can work quite well to dispel some commonly held misconceptions as to how risky certain activities are.

So, firstly, let's try to fully understand what a one-in-a-million chance is. One useful analogy is that it represents the same likelihood as tossing a coin 20 times and having it land heads up every time. You don't need to have a good grasp of probability to understand how unlikely this is and therefore how small this unit of a micromort of probability is.

Everyone would consider skydiving dangerous, and it is. According to world experts on the subject, skydiving increases your risk of dying by approximately eight to nine micromorts per jump (meaning you have roughly a one-in-100,000 chance of dying).

Interestingly, marathon running, an activity probably considered healthy, also increases your risk of dying by approximately seven micromorts per run. So if you are a marathon runner who is scared of jumping out of an aeroplane because of the risks, one might argue there isn't really a rational basis for this fear.

Scuba diving is another activity everyone would consider to involve significant risks. It increases your risk of dying by approximately five to ten micromorts per dive.

And for those of you who aspire to scale Mount Everest, this would expose you to a whopping 40,000 micromorts per ascent.

As a point of comparison, let's look at the risks of the very relatable activity of travel. Driving a car for 400km exposes you to approximately one micromort of risk. You would only have to ride a motorcycle for 10km to expose you to the same risk of dying, which puts into perspective how much riskier riding a motorbike is.

Aeroplane travel (by commercial jet), which strikes fear into some people, is very safe statistically. You would have to travel for more than 10,000km to be exposed to a micromort of risk.

If this makes you too afraid to leave the house, even mooching around the house has risks associated with it. Using "what Australians die of" data from the Australian Bureau of Statistics, sitting on a chair (due to the likelihood of falling off it) increases your risk of death by approximately 1.3 micromorts. Slipping and falling increases your risk of death by 13 micromorts. Just having a bath increases your risk of death by 0.3 micromorts.

Everything carries risk

So if the likelihood of being killed by a shark is approximately one in eight million over the course of the year, sharks increase our risk of death by 0.125 of a micromort per year. To put this in perspective, the yearly increase in our risk of dying in a shark attack is the same as the risk that many of us are willing to take in our commute to work and back each day. And it is nearly a hundred times less than the risk of drowning when you go swimming (approximately 12 micromorts).

Interestingly, kangaroos (approximately 0.1 micromorts) pose a risk of death that is similar to that posed by sharks, but our cute national emblem does not evoke quite the same fear in us.

Everything in life has risks and the art of living a good life is to be clear as to when risks are worth taking. Every day we get out of bed (which increases your risk of death by about 2.4 micromorts!) we make a trade-off between the risks associated with what we do and our enjoyment of life, even if we are not always perceiving these risks accurately.

QUESTION 1

Describe a micromort: **(2 MARKS)**

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QUESTION 2

Tabulate (create a table of) the data presented in the article quantifying the comparative risk of ***twelve*** different activities named in the article. **(8 MARKS)**

END OF PAPER