Science Puzzles is a collection of mixed puzzles from different areas of science. It emphasises the different ways of thinking (logical, lateral, critical, holistic and versatile). The 96 tricky puzzles in this book are designed to stretch your brain as well as educate and entertain. Most of the puzzles require no calculation or very simple calculations and appear simple until you try to solve them. Answers and solutions are given at the end of the book.

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TIMES EDITIONS

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PREFACE

This book aims to popularise creative thinking, problem solving and discovery learning skills that are crucial for the knowledge economy. It is a collection of interesting practical puzzles from physics, astronomy, geography, earth sciences, biology, chemistry and ethics.

The book is for everyone who is interested in science, with wide use anticipated in secondary schools. The book may be used to stimulate discussion and debate, both at school and at home. It is designed to be an effective 'brain gym', one that benefits all who are challenged to think about its contents.

The puzzles in the book are designed to both educate and entertain. It is so called 'edutainment genre'. Most of the puzzles have qualitative character and require no or very simple calculations. The emphasis is on different ways of thinking (logical, lateral, critical, holistic and versatile), paradoxical reasoning and common sense. Most of the puzzles appear simple until you try to solve them. Some of them are easy but the majority are quite tricky, thought provoking, challenging and even teasing. Often they have surprising answers and unexpected solutions for the reader. Some general principles such as the principle of parsimony are discussed in the context of the puzzles.

The puzzles will stimulate discussion and debate. Most of them appear simple until you try to solve them.

We have deliberately mixed very simple puzzles that need just seconds to solve with more advanced ones that require more time and effort. We have also mixed puzzles from different areas of science. You often won't immediately know how simple or hard it is to find the answer to a particular question or how it links to other areas. It is up to you, the reader, to estimate the level of difficulty and nature of a particular puzzle and make appropriate assumptions. Sometimes we purposely include unnecessary information in a puzzle, forcing the reader to differentiate between what is important and what is not for solving the puzzle. Some solutions have several levels of complexity and some, because of the diversity of the theories or hypotheses used to explain a phenomenon, do not have a unique answer. That is why in the Answers Section we sometimes provoke the reader to look at the puzzle from a different angle and answer it accordingly. All the above features make the book special.

The puzzles in this book are from a variety of different sources. Some were picked up from conversations with colleagues and friends, some

were created or converted into a different context by the authors and some were just the questions often asked by children. In most cases it is impossible to identify the author of any puzzle as one can encounter many different versions of it in different books published in many languages. Often the authors of famous old puzzles are unknown. These puzzles (like Size of the Moon) are part of folklore.

We hope that you will enjoy solving the puzzles, sharing and discussing them with family, friends, teachers and colleagues in the same way that we did when writing this book. Science is truly fun. Enjoy it!

John Buckeridge
Sergei Gulyaev
Sergiy Klymchuk

October 2003
Auckland, New Zealand

INTRODUCTION

The questions in this book fall into two groups: those that *appear* to be relatively simple concepts and those that *are* a little more complex.

In all the questions, we challenge you to think a little more about the 'how?', the 'why?', and the 'what if?'. Along with the question, we have provided an overview, sometimes with references that we feel may help you to search for the truth.

Much of your thinking in solving problems involves high activity in the left cortex of your brain. *Left Brain Thinking* is logical, sequential, rational, analytical, objective and reductionist, i.e. focusing on parts.

Right Brain Thinking, however, is more involved with random, intuitive, holistic, synthesis subjectivity and focuses upon the whole, aesthetics, feeling and creativity.

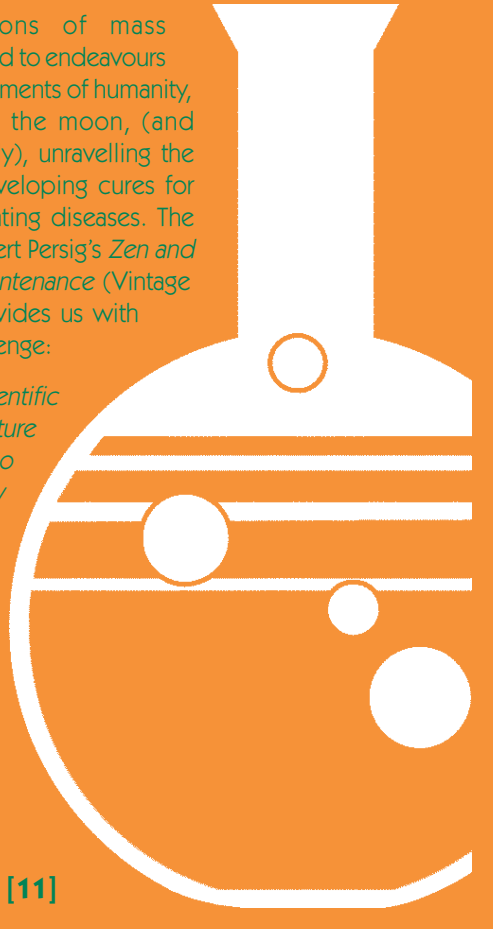
Most of us have a distinct preference for one of these styles of thinking although, on occasions, some individuals are more 'whole brained' and are equally adept at both modes. In general, approaches in mathematics and sciences tend to favour left-brain modes of thinking and may even marginalise right-brain modes. It follows recognition of the effects that human activities have had upon our environment: pollution, loss of biodiversity, erosion, salination and the possibility of accelerated global warming that scientists are now asked to think beyond the science…to contemplate effects (Buckeridge, J.S., *Ethics and the Professional*, Lyceum Press, Auckland, 2002).

Ever since humans became aware that they could effect change in their environment, they have experimented with and asked questions about their surroundings. In all cases, this search for answers involved a natural curiosity, which typifies us as a species. This may have been driven by necessity, such as the development and manufacture of weapons and of manageable fire, but the search also involved more esoteric concepts, such as explaining ourselves in space and time. Some of the results of these intellectual pursuits may lead to the dark side, such as the manufacture of weapons of mass destruction. Others may lead to endeavours that typify the highest attainments of humanity, such as landing men on the moon, (and retrieving them successfully), unravelling the basis of heredity, and developing cures for some of the most debilitating diseases. The following quote, from Robert Persig's *Zen and the Art of Motorcycle Maintenance* (Vintage Press, London, 1974), provides us with both a warning and a challenge:

The real purpose of the scientific method is to make sure Nature hasn't misled you into thinking you know something you actually don't know.

Embrace this thing we call Science!

[The puzzles will stimulate discussion and debate. Most of them appear simple until you try to solve them.]



THE PUZZLES

Sailing

A yacht returns from a round-the-world trip.

Which part of the yacht has covered the greatest distance?

1

Encircling the Earth

Imagine a rope around the Earth's equator (ignore the mountains and deep-sea trenches). Add 20 metres to the rope and form a circle again.

How high approximately will the rope be above the Earth? A) 3 mm B) 3 cm C) 3 m

2

Jets and Buses

When turning, a plane leans inwards but a bus leans outwards.

Why?

3

Two Men and a Boat

Two men approached a river. There was a single-seat boat on a bank. Nevertheless, the two men crossed the river in the boat and went on their way.

How could they do this?

4

Water Skiing

Can a water skier move faster than the boat pulling him/her?

5

Insect Wings

If you look at the wings of some insects (beetles, dragonflies) from different angles, the colours of their wings change.

Why?

6

Balloons

Is it possible to use sails to change the direction in which an airborne hot-air balloon moves?

7

Bicycles

Often the bottom spokes of a moving bicycle can be seen clearly whereas the top spokes cannot.

Why is this so?

8

Blue Sky?

Most of us are fairly confident that air is colourless.

If this is so, then why is the sky blue?

9

Candles

The flame of a candle is sharp at the top.

Why?

10

Gravity

Give an example of two objects moving towards each other with the gravitational force between them decreasing.

11

Trains

A local train left city A for city B at the same time as an express train left city B for city A. They passed each other on their respective journeys. The express train and local train arrived at their destinations respectively 1 hour and 9 hours later after they met.

How much faster is the express train compared to the local train?

12

Standing up

Why is it not possible to stand up from a chair without bending your body or moving your feet under your body?

13

Apples

When you shake up a bucket with apples of different sizes the largest apples will appear on the top.

Why?

14

Wind

Does wind affect thermometer readings?

15

Lakes

Why do lakes in frosty winters freeze earlier than rivers in the same area?

16

Compass-1

On which part of the Earth does the magnetic needle of a compass indicate south with both ends?

17

Compass-2

Is it possible to navigate on the Moon using a compass?

18

Insect Sound

When flying, many insects make a sound.

How is the sound produced?

19

Insect Speed

When flying, which insect beats its wings at a faster rate – a housefly or a mosquito?

How can you determine this?

20

Dead on the Spot

A soldier who returned from the war attended a church service with his wife. During the service he suddenly fell asleep. He dreamed that his enemies had caught him and an executioner was raising his axe… Exactly at that moment his wife tapped his neck with her fan to wake him up. The shock was so great that the soldier instantly died. This story cannot be true.

Why?

21

Cooling Water

Two metal kettles of the same shape but different capacities are completely filled with boiling water. They are then covered.

Which kettle will cool down faster?

22

Into Darkness

Yesterday I turned off the light and managed to get into bed before it became dark. The distance between the light switch and the bed is 3 metres.

How could I do that? (The speed of light is 300,000 km/s.)

23

Snail

A snail climbs a 15-metre pole. It goes 4 metres up during the day and 3 metres down during the night.

How many days does it take for the snail to reach the top of the pole?

24

Berries

There were 100 kg of berries in a shop two weeks ago. The moisture content of these berries was originally 99% but has fallen to 98%.

What is the weight of the berries now?

25

Clocks

The wall clock ticks 5 times in 8 seconds.

How long does it take to tick 10 times?

26

Train Journey

One train left A for B at a speed of 90 km/h. Another left B for A at a speed of 70 km/h. Both trains were non-stop.

What was the distance between them 1 hour before they met?

27

Spaceships

Two spaceships are approaching each other; the first spaceship at a speed of 90% of the speed of light, the second spaceship at 70% of the speed of light. (The speed of light is 300,000 km/s.)

What is the distance between them 1 second before they meet?

28

Car Journey

A car was driven from A to B at a speed of 60 km/h and back from B to A at a speed of 40 km/h.

What was the average speed of the entire trip if the car did not stop?

29

Bones

Some of our bones have a tubular (hollow cylindrical) structure. This is important for us.

Why?

30

The Tunnel

A train 1 km long is travelling at 60 km/h when it enters a tunnel that is also 1 km long.

How long does it take the train to go through the tunnel?

31

Lilies

Imagine a lake on which water lilies are growing. Observations show that the area covered by the lilies doubles each day. The whole lake was covered in 16 days.

How long did it take the lilies to cover half of the area of the lake?

32

Size of the Moon

We have all experienced a full moon, close to the horizon. Often we are enchanted by the apparent change in size of the Moon, especially when, later in the night, it is overhead and appears much smaller.

Is the Moon in fact smaller when overhead (as compared with when it is nearer the horizon) or is this an optical illusion?

33

Bacterial Growth

Certain bacteria double their number every second. If you placed one such bacterium on an empty 100-mm agar plate, it would take 1 minute for bacteria to fully colonise it.

How long would it take to fully colonise the same plate if you initially put two bacteria on the empty agar plate?

34

Age

A girl claims that she was 12 the day before yesterday, and next year she will be 15.

What are the conditions for such a claim?

35

Gem Colour

One of the rarest and most expensive gemstones, alexandrite, changes colour from green in daylight to red in incandescent light.

How can this be so?

36

Water and Wine

There are two barrels: one containing wine and the other water. You take a glass of wine, pour it into the barrel of water and mix thoroughly. Then you take a glass of the mixture and pour it back into the barrel of wine.

Which is more: the amount of wine in the water barrel or the amount of water in the wine barrel?

37

Pets

A biologist randomly put a kitten, a puppy and a lamb into cages with names: Kitten, Puppy, Lamb.

What are the chances that exactly two pets would get their designated cages?

38

Sand and Sea

Why do some sandy beaches behave like quicksand when walked upon, whilst others remain firm, even when wet?

39

Six Glasses

There are six glasses in a row on a table. The first three are full of water, the others are empty.

How can you have them alternating by touching just one glass?

40

Geography

Can you be in a spot in North America that lies to the east of some spots in Europe?

41

Climbing

A geologist begins climbing a volcano at 6 a.m. and reaches its summit at 6 p.m. The next day he starts his descent at 6 a.m. using the same path and comes back to the bottom of the volcano at 6 p.m.

Prove that there is a spot on the path where the geologist was, at exactly the same time of day, on both days.

42

Buses

A bus left Berlin for Paris at a speed of 80 km/h. One hour later another bus left Paris for Berlin at a speed of 100 km/h.

Which bus will be further from Berlin when they meet?

43

Free Beer

On arrival a traveller was overjoyed to see a poster in his hotel bar stating: Free Beer Tomorrow. However, when he tried to get free beer in the bar the next day he was disappointed.

Why?

44

Destination North

Is there a place on the Earth, from which any movement would be to the North?

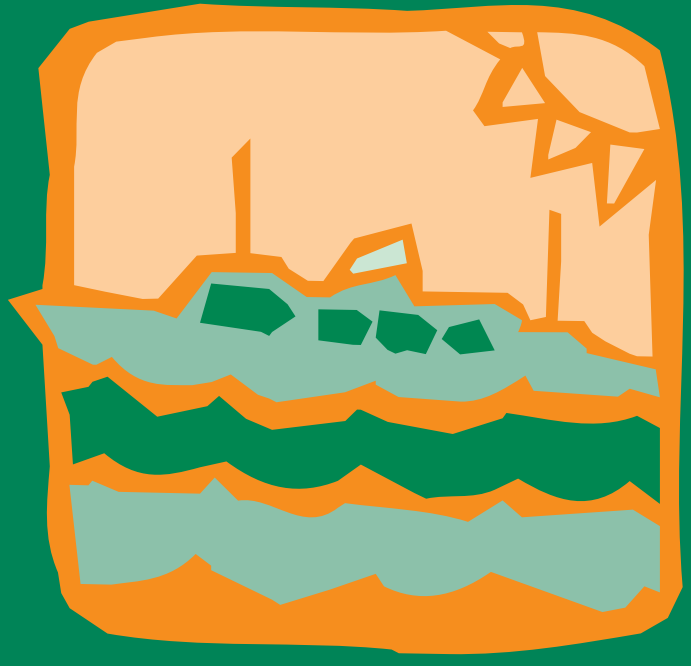
45

Voyage-1

A ship left Sydney at midday on Saturday, 8 November, and arrived at San Francisco in the afternoon of Wednesday, 26 November.

How many days did the journey take?

46



Voyage-2

A ship left San Francisco in the afternoon Saturday, 8 November, and arrived in the port of Auckland (New Zealand) exactly 19 days later.

What date and day of the week did she arrive?

47

Sunlight

How long does it take for light to travel from the Sun to the Earth?

48

Night Sky

Why is it dark in the night?

49

Opening Doors

Why is it that your finger pushes a door open whereas a speeding bullet will make a hole in the door instead of pushing it open.

(Please don't try this at home.)

50

Red and White Socks

I have 20 red and 20 white socks. They are mixed together. I want to pick out a pair of socks of the same colour in a dark room.

What is the minimum number of socks I need to select to have a matching pair?

51

Brakes

A bicycle has two brakes: one for the front wheel, the other for the rear.

In what order should you push the brakes when you need to stop suddenly?

52

Yachts

Why does a yacht need a keel?

53

Jumping on the Moon

It is known that the gravity on the Moon is 6 times less than it is on the Earth.

Is it possible for a sportsman, who can jump 2 m high on the Earth, to leap 12 m above ground on the Moon?

54

Cup of Coffee

I leave a cup of hot coffee on the table for a couple of minutes. I can add cold milk to it before I leave (option 1) or I can do it when I return (option 2).

Which option would keep the coffee hot longer?

55

Riverbanks

In the Southern Hemisphere the left bank of a river is generally steeper than the right one.

Why?

56

Leaf Patterns

If you look at the arrangement of successive leaves on a single stem plant, you will find that they are arranged in a particular pattern.

What is this pattern? Is it only in plants?

57

Weightlifting

As gravity varies in different places, the effort required to lift 100 kg changes accordingly.

In light of this, is it important to state where the world championship in weightlifting is held to compensate for any regional variations?

58

Tyres

Why do tyres on cars and trucks have treads? Why does the tread extend both longitudinally and laterally?

59

The Glass of Water Experiment

Fill a glass with water and cover it with a thick piece of paper or cardboard. Turn the glass upside-down, holding the piece of paper firmly against the glass. Take away your hand.

Explain the result of your experiment.

60

River Surface

Is the surface of a river horizontal?

61

Iron Ships

Iron sinks in water. Ships are made of iron.

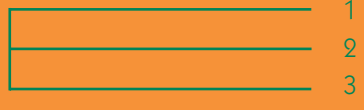
Why do they not sink?

62

Water Lines

All ships have a 'plimsoll line', i.e. the water line that marks the maximum level to which the hull can be submerged. Sir Peter Blake (the famous New Zealand sailor) has travelled on his ship *Seamaster* in both Antarctica and on the Amazon River.

Which mark corresponds to the waterline in the river, in the cold sea water (near Antarctica) and in the warm sea (near New Zealand)?



63

Two Balloons

Two balloons are filled with hydrogen. One is made of rubber, the other is made of rubberised cotton fabric.

Which one will reach the higher altitude? (Assume that there is no leakage of hydrogen.)

64

Balloons on the Moon

Can hydrogen balloons fly on the Moon?

65

Missile Protection

To protect a fighter plane from being attacked from the rear, a non-controlled missile was once installed on the rear of the plane. When testing the missile, a surprising fact was established. When launched, the missile turned around and pursued the plane.

Can you explain this behaviour?

66

Up and Down

What is it that goes up and goes down but does not move?

67

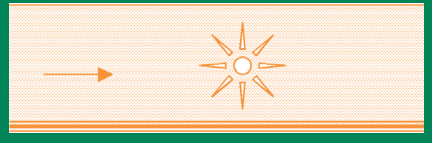
Feather and Lead

Which is heavier: one kg of feathers or 1 kg of lead?

68

River Flow

The river in the figure below flows from left to right. Describe the rotation of the wheel in the river.



69

Blue Blood?

If blood is red, why do blood vessels look blue?

70

Hurricanes

Hurricanes may lift the entire roof off a house without completely destroying the walls.

How can this happen?

71

Graphite and Diamond

Graphite and diamond are different forms of naturally occurring carbon (they are called 'carbon allotropes').

a. Why is graphite more abundant in nature than diamond?
b. Why is diamond harder than graphite?
c. What other *natural* allotrope of carbon do you know?

72

Refrigerators

Will the air temperature in your room change if you open the door of your refrigerator and leave it open for an extended period?

73

Lead Roofing

Lead sheets are used to cover the roof of Bristol Cathedral. It was found over a two-year-period that the lead sheet covering the southern part of the roof had gradually moved down the roof some 50 cm. (The movement started after the roof was covered with lead sheets). Nails put into the sheet couldn't stop the movement because the moving sheet tore them out. The roof is not particularly steep, and friction between the wooden rafters and the lead sheet was large enough to prevent simple sliding down because of gravity.

Why did the sheet slide down?

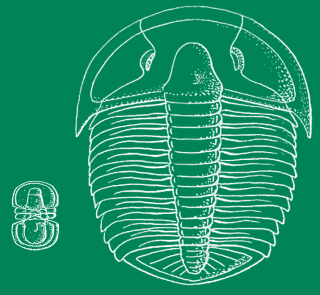
74

A Problem in Logic

Redundancies in Nature: In general, animals and plants have structures for a purpose. From this we have the maxim *form reflects function*. Nature is **economical**, such that when structures are not needed, they fail to develop. If the circumstances of the organism change, and they are no longer appropriate for a particular way of living, redundant structures disappear after a number of generations. This may be what is happening with our appendix (although we should be cautious here, as the role of the appendix may not be fully understood).

Eyes and fossils. Fossils are evidence of past life. In most cases, they only give us a very fragmentary idea of what they, and what their environments, were like. Rarely do fossil deposits give us more than this. However, when excellent preservation happens, we may find organisms preserved as they were living immediately prior to death. In mud that was deposited in the Cambrian period (about 550 million years ago), in Utah, USA, small arthropods, called trilobites were preserved.

75



The Wheeler Shale deposits contain one of the best-preserved trilobite faunas in the world. Two of the more abundant species include *Elrathia kingi* (pictured above) that had eyes, and the smaller *Peronopsis interstrictus*, that was blind. Note the relative size differences.

The two species occur in the same beds, often being found immediately adjacent to each other. The remains of both types are generally well preserved, i.e. they are not moults. In addition to the trilobites, large carnivorous arthropods, like enormous, plated scorpions, lived in the area. These are known as eurypterids. (continued)

Devise a theory to account for their co-existence in the light that:

1. organisms develop and retain eyes only when there is sufficient light to see with.
2. eyes are complex structures and are easy to recognise when present on organisms.
3. organisms lose eyes when there is no need for them.
4. trilobites are sophisticated arthropods that fed by scavenging, predation and grazing.
5. trilobite-eating eurypterids lived in the same environment.

Is it possible to produce a falsifiable theory when dealing with extinct species?

75

What Happened at the End of the Cretaceous?

This is 'one of the really **big** questions'. As such, we will include a little more background in anticipation that you may make an informed conclusion.

The Cretaceous period ended some 65 million years ago. What was really remarkable about the end of this period was the mass extinctions: more than 70% of all living organisms on Earth became extinct. The reasons for massive extinctions like this are still not clear but there are a number of theories, ranging from rapid climatic fluctuations, disease, anoxia (decreased availability of oxygen), sea level changes, volcanicity, orogeny (a period of mountain building), hypersalinity and meteorite impact. These theories are all supported, to some degree, by palaeoenvironmental (studies of the ancient environment), palaeogeographic (studies of ancient geography) and palaeontological (studies of ancient life forms) observations.

Why do you think the dinosaurs died out at the end of the Cretaceous?

76

Balance Scale

Two balls of the same weight are hung from the bottom of a balance scale – one on each side – so that the scale is in equilibrium. One ball is made of glass whereas the other is of lead. The balls were put into a container with water.

Would the scales be in equilibrium?

77

Burning Gas

Can you put out a gas-fuelled fire using only water (from a hose)?

78

Ice-Cream

A strong breeze from a fan makes you feel cool.

Would it affect the rate at which ice-cream melts? If yes, in which way?

79

Which Eclipse?

An eclipse is shown schematically on the diagram below.

Is this a solar eclipse or a lunar eclipse?

80

Dark Moon

In the diagram for question 80, the Earth screens the Moon from the sunlight, so the Moon is fully covered by the Earth's shadow.

When this happens, can we still see the Moon from the Earth?

81

Weightless Astronauts

Is weak gravity a reason for the fact that astronauts can float around on the Space Station?

82

The Bookworm

Three volumes of an encyclopaedia sit on a bookshelf. In each volume the thickness of all inside pages totals 9 cm, and each cover (front and back) is 0.5 cm thick. A bookworm eats from the outside of the front cover of the first volume through to the outside of the back cover of the third volume in a straight line.

How far does the bookworm travel through the books?

83

A Sail Boat

When a large sail boat approaches a shore, the first thing an observer on the shore would see is the top of its highest mast, then the sails, and then the body of the boat.

Does this information prove that the Earth is 'spherical'?

84

The Moon

Does the Moon rise every day?

85

Driving a Car

Before driving a car or a truck on soft soil, sand or snow, it is advisable to release some air from the tyres.

Why?

86

Ice and Water

A cube of ice floats in a glass of water.

Would the level of the water in the glass change when the ice has melted?

87

Estimating Depths

Estimating the depth of a swimming pool using our eyes often leads us to underestimate the depth.

Why?

88

Water Temperature

What is the temperature of water in an unheated, open container in a room?

Will it be the same as, more than, or less than the temperature of the air in the room?

89

Melting Ice

A piece of ice does not start to melt immediately when you bring it into a warm room.

Why?

90

Ice and Fire

Is it possible to get fire from ice?

91

Just How Safe Is Cola?

If I place a dirty alloy coin in a glass of cola, it becomes 'clean'. Why does this happen, and does a glass of cola harm our stomach when consumed?

92

What Makes an Echo?

Why do echoes occur in empty rooms but not in forests?

93

Why Do We Shiver on Mountaintops?

Heat rises... Why then does it get colder when one climbs a high mountain?

94

Opening the Refrigerator...

If I shut a refrigerator door and immediately try to open it, it appears to require much more energy to open than previously.

Is this really the case or is it imagination?

95

Green Flashes at Sunset

There is widespread belief that when the Sun sets below a sea horizon, a green flash occurs, just as the Sun vanishes.

Does this really happen or is it an optical illusion?

96

THE ANSWERS

1. Sailing

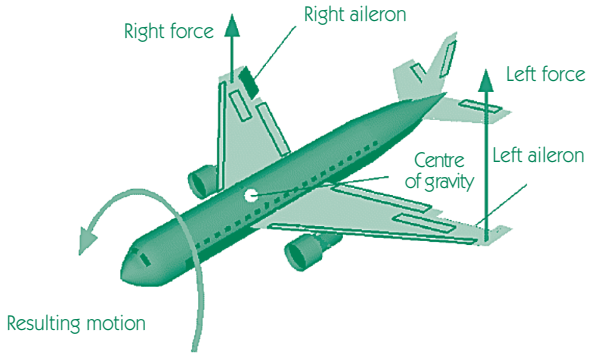
The top of the yacht has covered the greatest distance. The distance from the centre of the Earth to the top of the yacht is the longest compared to the other parts of it. Therefore, it has encircled the longest circumference.

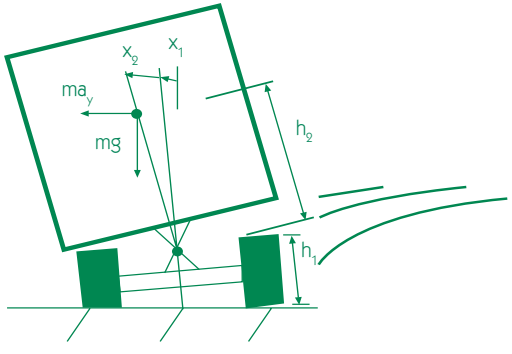
2. Encircling the Earth

Approximately 3 m high. This is a surprising answer for many people. Let r be the radius of the Earth and R be the radius of the circle after adding 20 metres to the rope. The difference between the two circumferences is 20 m: $2\pi R-2\pi r=20$ or $2\pi(R-r)=20$. From here the difference between the two radii is $R-r\approx 3$ m.

3. Jets and Buses

An aeroplane flies because its wings generate 'lift' – a vertical force that works against gravity. During a turn, the pilot moves the joystick to adjust the ailerons such that one wing is producing more lift than the other. The plane banks to one side, and lift is created in both vertical and horizontal directions. The horizontal component of lift causes the plane to turn.





Changing the direction of the wheels, which grip the road surface due to friction, manoeuvres a bus. During a turn, the centrifugal force, which is effectively applied to the centre of inertia of the bus, makes the bus lean outwards. So, an aeroplane turns because it leans. On the contrary, a bus (or a ship) leans because it turns.

4. Two Men and a Boat

The two men approached the river from different sides. (Read the question carefully!)

5. Water Skiing

Yes. Here are a couple of examples. The skier would move faster:

- When he/she pulls the rope in.
- When the boat is turning (the skier goes along a circle with a greater radius than that of the boat and therefore covers a greater distance than the boat in the same time).

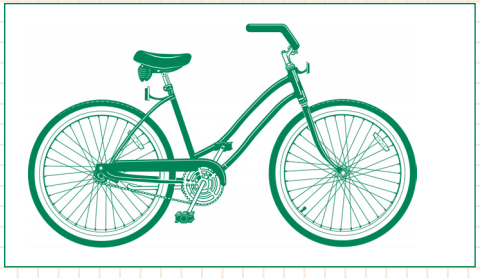
6. Insect Wings

The transparent membranes of different thicknesses that comprise the wings of some insects give optical

interference (originating from the superpositioning and reflection of different light wave fronts). A similar effect is seen when a drop of oil is placed on a water surface.

7. Balloons
No, the hot-air balloon has the same velocity as the wind.

8. Bicycles
The velocity of the bottom spokes relative to the ground is lower than the velocity of the top spokes.



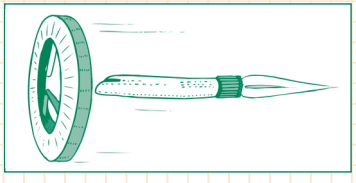
9. Blue Sky?
Oxygen appears colourless as a gas. You may have made some in your class laboratory. Certainly it is described in most chemistry texts as being a 'colourless, odorless gas'.

On a clear day, the sky is blue because molecules in the air scatter blue light from the Sun more than they scatter red light. However, if one looks at the Sun at sunset, one may see red and orange colours. This is because the blue light has been scattered out and away from the line of sight.

10. Candles
Hot air from the top of the candle rises. It is replaced by cooler air from below. This air rises up around the candle. When it reaches the flame, it is moving slower than the air in the middle and upper part of the flame. The net effect of this is for the incandescent area to elongate – with the top extending furthest.

11. Gravity

(a) A ring and a ball: With the ball moving towards the centre of the ring along an axis passing through the centre of the ring perpendicular to the ring's plane. By virtue of the symmetry in the situation, the gravitational forces from the ring particles on the ball cancel. E.g. it could be a shuttle craft approaching a ring-shaped space station. When the shuttle gets closer to the centre of the station, the gravitational forces between the station and the shuttle decrease. See the diagram.



(b) A probe moving towards the centre of the Earth. Newton showed that the gravitational force felt by a test particle at some point *inside* a spherically symmetric body (i.e., $r < R$, where r is the distance from the centre of the mass and R is the radius of the spherically symmetric body) is equivalent to the gravitational force due to a point mass at the centre of the mass with mass $M(r)$, where $M(r)$ is the total mass contained inside radius r. This nontrivial fact can be proved using calculus and was one of the highlights of Newton's *Principia Mathematica* (1687).

12. Trains

The express train is three times faster than the local train. There are many ways to solve this puzzle.
Here is one of them.
Let v_1 be the speed of the express train and v_2 be the speed of the local train. Then the distances covered by the local and express trains before they met can be expressed as $s_1 = v_1 \times t$ and $s_2 = v_2 \times t$. The ratio of these distances is the same as the ratio of the speeds: $\frac{s_1}{s_2} = \frac{v_1}{v_2}$.

After the trains met, the remaining distances covered by the two trains are $s_1 = v_2 \times 9$ and $s_2 = v_1 \times 1$ which gives us the ratio $\frac{s_1}{s_2} = \frac{9v_2}{v_1}$. Equating the right hand sides of the two ratios, we obtain $\frac{v_1}{v_2} = \frac{9v_2}{v_1}$. From here $[\frac{v_1}{v_2}]^2 = 9$ and $\frac{v_1}{v_2} = 3$.

Here is a slightly easier way. First, notice that the ratio of the distances covered by the trains before they met is the same as the ratio of their speeds. Secondly, the ratio of the same distances after the trains met is reciprocal to the

ratio of the speeds with the coefficient 9. So if R is the ratio of the speeds, we have:
$R = \frac{9}{R}$ or $R^2 = 9$ or $R = 3$.

13. Standing up
To be able to stand up from a chair, the vertical line from your centre of gravity must cross the support area (your feet). Otherwise you will topple over.

14. Apples
Any system tends to take the most stable condition. This corresponds to the minimum level of potential energy. In order for the bucket's centre of gravity to be lowest (i.e. giving the minimum potential energy) the apples should fill the lower part of the bucket in the densest way. This happens when smaller apples fill most of the space of the lower part of the bucket.

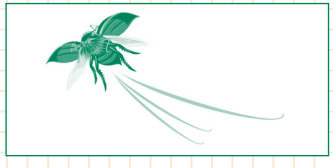
15. Wind
No, unless the thermometer is wet, in which case the temperature of the thermometer is lowered due to heat lost during evaporation of the water.

16. Lakes
Because the current of a river brings the warmer water from the bottom up to the surface.

17. Compass-1
On the North Pole.

18. Compass-2
No. Unlike the Earth, the Moon has no global magnetic field.

19. Insect Sound
By vibrating their wings. In flight, insects beat their wings at between 4 and 1000 beats per second. The beating produces waves of compressed and rarified air, which we interpret as sound.



20. Insect Speed

The mosquito – it makes a higher sound when flying. Insects such as mosquitoes and midges may beat their wings up to 1000 beats per second. These produce a high-pitched sound. Houseflies beat their wings at 190 beats per second which produces a lower pitch. Butterflies are so slow (about 4 beats per second) that the sound they produce is inaudible to humans.

21. Dead on the Spot

Since the soldier died instantly, we cannot know what he was dreaming about.

22. Cooling Water

The smaller kettle will cool down faster. Let us assume for simplicity that both kettles are spherical. Let us say that the radius of the bigger kettle is n times more than the radius of the smaller kettle. Then, the surface area of the bigger kettle is n^2 times more than the surface area of the smaller kettle and the volume of the bigger kettle is n^3 times more than the volume of the smaller kettle. Obviously the volume of the bigger kettle per one unit of surface area is n times more

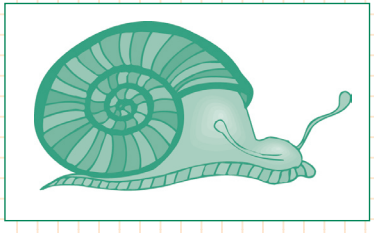
than the volume of the smaller kettle per one unit of surface area. Therefore, the smaller kettle has n times bigger surface area per one unit of volume which makes cooling faster.

23. Into Darkness

I went to bed during the day.

24. Snail

12 days. After 11 days and nights the snail is 11 metres high on the pole. Climbing 4 metres on day 12, it reaches the top of the pole.



25. Berries

50 kg. Two weeks ago the solid content was 1% of 100 kg, that is 1 kg. The weight of the solid content remains the same – only moisture vaporises. Since the moisture

content now is 98%, the solid content is 2% which is still 1 kg. To get the total weight (100%) now we need to multiply 2% (which is 1 kg) by 50.

26. Clocks

18 seconds. Ticking 5 times means that there are 4 intervals, and each interval is 2 seconds. Ticking 10 times means that there are 9 intervals. Therefore at 2 seconds per interval it takes 18 seconds to tick 10 times.

27. Train Journey

160 km. The two trains were approaching each other at a relative speed of 90 km/h + 70 km/h = 160 km/h according to Galileo's Relativity Principle: $u = v_1 + v_2$.

28. Spaceships

Unlike in the previous question we cannot just add the two speeds because the resulting speed will exceed the speed of light, which is considered impossible. In fact, the resulting speed will be slightly less than the speed of light. Therefore, the distance between the two spaceships 1 second before they meet is slightly less than 300,000 km. To get a more accurate result in cases where the speed is comparable to the speed of light, we should use the

formula based on Einstein's Principle of Relativity: $u = \frac{v_1 + v_2}{1 + \frac{v_1 \times v_2}{c^2}}$. This gives us the answer u = 0.98c = 294,000 km/s, a relative speed at which the two spaceships were approaching each other. So the distance between them 1 second before they meet is 294,000 km.

29. Car Journey

48 km/h. There are many ways to solve this puzzle. The 'arithmetic' method: Since the distance between A and B is not given, let us choose any 'good' number, say 120 km. Then it takes 2 hours for the journey from A to B and 3 hours from B to A. So it takes 5 hours for the entire trip of 240 km. The average speed therefore is 240 km/5h = 48 km/h.

The algebraic method: The average speed for the entire trip is (total distance)/(total time). Let S be the distance between A and B. Then the total distance travelled by the car was 2S. It took $\frac{S}{60}$ hours for the car to travel from A to B, and $\frac{S}{40}$ hours to travel from B to A. So the total time was $\frac{S}{60} + \frac{S}{40} = \frac{5S}{120} = \frac{S}{24}$ hours.

Therefore the average speed was $\frac{2S}{(\frac{S}{24})} = 48$ km/h.

30. Bones

Bones are 'engineered' for maximum strength for their weight. They are frequently hollow at the centre of their shafts where the main stress is a bending stress. A hollow tube is stronger for its weight than a solid rod of the same weight.

31. The Tunnel

2 minutes. From the moment the front of the train enters the tunnel to the moment the back of the train leaves the tunnel, the train covers 2 km. At the speed of 60 km/h or 1 km/min it takes 2 minutes to cover 2 km.

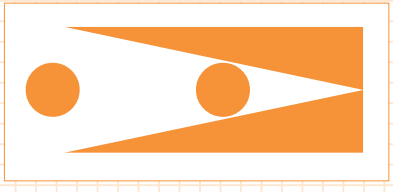
32. Lilies

15 days to cover the initial half. On the 16th day, the lilies doubled half of the area of the lake to cover the whole lake.

33. Size of the Moon

Objects may appear larger to us because of one, two or all three of the following reasons: they have moved closer to us; and/or they are magnified; and/or if they have increased in size. We can be confident that the Moon's radius (1738 km) is not changing.

In light of this, your first response may be that the Moon is not at all larger. Rather it just appears small when it is at its culmination. Valid reasons could be the lack of anything nearby for comparison. It is isolated in space and thus *appears* small.



The figure above may help to explain this phenomenon. The two circular objects are the same size. The one to the right, however, appears to be larger. Its position, filling the entire space between the two converging lines, gives us the illusion that the circles are different sizes.

Further thought may lend you to reflect upon the magnifying effect of the Earth's atmosphere. This causes refraction of the reflected moonlight and does change the size of the image, although this change is only in the order of about 2% and will not be readily noticed by the human eye. If this is your first conclusion to the puzzle, you are not alone, as the great philosopher Aristotle (384–322 BC) also attributed the illusion to the refraction of light by the atmosphere.

The final aspect that may be considered is the orbit of the Moon around the Earth. This orbit is not a perfect circle; it is an ellipse. As such, the Moon's distance from the Earth varies; however, this is not sufficient to account for the apparent difference in size that we are investigating.

Conclusion: The moon does *appear* larger when closer to the horizon. Although there is no single reason for this, an optical illusion (the Moon being lost in vast space overhead) is the most important contribution to our perception.

34. Bacterial Growth

59 seconds. Since we start with two bacteria, we have

one step less, namely where the first bacterium reproduces to two. This takes 1 second, saving 1 second from the total time from when we started with 1 bacterium. Therefore the answer is 60 – 1 = 59 seconds. Of course, the size of the agar plate (100 mm) is not essential information here.

35. Age

She makes her claim on 1 January and her birthday is on 31 December.

36. Gem Colour

Alexandrite, a variety of the mineral chrysoberyl $BeO.Al_2O_3$, was discovered in Russia's Ural Mountains in 1830. It was named after Tsar Alexander II, as it can be both red and green (the Russian imperial colours).

The colour of alexandrite is due to very small amounts (traces) of chromium. The colour depends on both how light is reflected and refracted by the crystal and on the nature of the chemical bonds within the crystal. The position of the chromium atoms within the crystal lattice is such that it can provide either a red or green colour, depending upon the nature of the light falling upon the crystal. (Experiment with a yellow sheet of paper under

an orange sodium streetlight and you will see what we mean – the paper appears *white*). Although the range of wavelengths of natural sunlight and incandescent light are similar, the amount of light at the *blue* end of the spectrum in natural light is greater. As a result, the crystal will appear green. However, with incandescent light, the red end of the spectrum is dominant, and the crystal appears red.

37. Water and Wine

The same. The amount of water added to the barrel of wine replaced the same amount of wine that was added to the barrel of water. We can repeat this two-step 'procedure' many times and always the amount of water in wine would be the same as the amount of wine in water.

38. Pets

Zero chances. If two of them get into their designated cages, then the third will automatically get his/her 'own' cage. So the situation 'exactly two' is impossible.

39. Sand and Sea

Sand on the beach (or anywhere for that matter) behaves like quicksand when it has low shear strength. The first

and primary cause is grain shape. If sand grains are round and possess high sphericity, they will act like tiny **ball bearings** when loaded. If you were standing on such a beach, you would sink into it, irrespective of whether it was dry or wet. In deserts where there is constant weathering and erosion, the grains are reduced to almost perfect spheres. The weathering process often polishes grains from this environment, with individual grains developing a **desert varnish**.

A second reason why sands lack shear strength is the movement of groundwater. In particular, if there is a rising water table, grains become lubricated, friction drops, and they slide past each other more easily. This often happens during earthquakes, when fluids that are held between loosely packed sand grains are quickly released. A third reason why some sands may appear firmer than others is cementation. On hot days, on a falling tide, any seawater that lies between sand grains evaporates, leaving behind salt. This salt crystallizes and glues sand grains, especially at the air-surface interface, where a crust of cemented sand may develop. When the tide comes in, the salt dissolves, and the grains become loose again.

40. Six Glasses

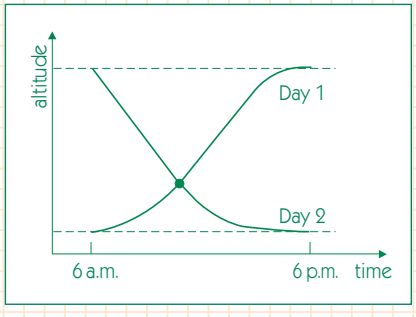
Pour water from the second glass into the second empty glass and put it back.

41. Geography

Yes, you can. Greenland is part of Europe. Some parts of it are to the west of the eastern parts of North America. Another way to look at this puzzle is to remember the spherical shape of the Earth. Then the whole continent of North America can ultimately be considered to be to the east of Europe.

42. Climbing

One way to solve this puzzle is to draw a diagram of the geologist's path on both days.



The point of intersection corresponds to the spot on the path where the geologist was at exactly the same time of the day on both days.

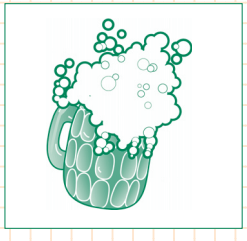
The other way to solve it is to replace this puzzle with an equivalent one where two geologists on the same day move towards each other on the same path from 6 a.m. to 6 p.m.: one from the bottom to the top and the other from the top to the bottom. There is a spot on the path where they meet.

43. Buses

Both buses will be at the same distance from Berlin or from any other point when they meet.

44. Free Beer

The beer is only available tomorrow…Tomorrow never comes…



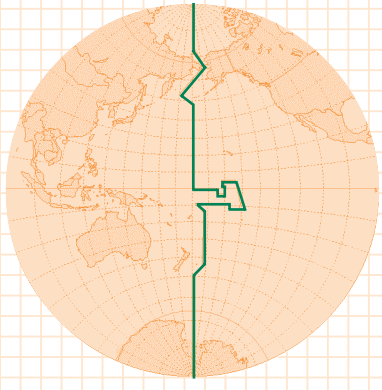
45. Destination North
The South Pole.

46. Voyage-1
About 19 days. Although direct mathematical procedure gives 26-8 =18 days, the fact that the ship crossed the International Date Line should be taken into account.

The International Date Line is the imaginary line on the Earth that separates two consecutive calendar days. That is, the date in the Eastern hemisphere, to the left of the line, is always one day ahead of the date in the Western hemisphere.

Without the International Date Line, travellers going westward would discover that when they returned home, one day more than they thought had passed, even though they had kept careful tally of the days. This first happened to Magellan's crew after the first circumnavigation of the globe. Likewise, a person travelling eastward would find one less day than he had recorded, as happened to Phileas Fogg in Jules Verne's *Around the World in Eighty Days*.

The International Date Line can be anywhere on the globe. But it is most convenient at 180° away from the defining meridian that goes through Greenwich, England. This area is mainly ocean. However, there have always been zigzags in it to allow for local circumstances. For example, on 1 January, 1995, The Republic of Kiribati, formerly known as the Gilbert Islands, moved the International Date Line to include its entire territory to the western side of it and prevent the country from being in two different days. As a result, the line has an eastward extension near the equator.

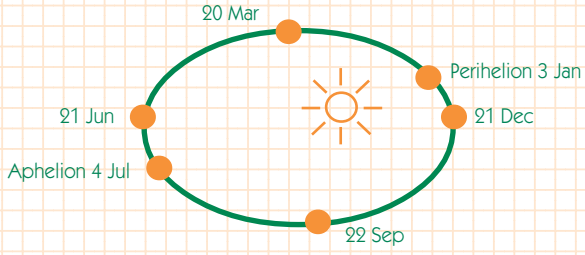


47. Voyage-2

Friday, 28 November. See the answer to the previous puzzle.

48. Sunlight

It is easy to calculate. The mean distance between the Sun and the Earth (one 'astronomical unit') is equal to 149,597,870.691 kilometres ~ 150 million km. Dividing this distance by the speed of light c = 300,000 km/s, we get average T = 500 seconds = 8 minutes and 20 seconds. However, the Earth does not rotate in a circle around the Sun but in an oval shape called an ellipse, so the distance between the Earth and Sun varies over the course of a year. Our distance from the Sun changes from a maximum of ~152.5 million km (aphelion), reached during the first week of July, to a minimum of ~147.5 million km (perihelion) during the first week of January. As a result, the value of T is some 17 seconds less in January than in July.



49. Night Sky

The simple observation that the night sky is dark allows far-reaching conclusions to be drawn about the large-scale structure of the Universe. The so-called Olbers paradox states the following: *If the Universe were spatially and temporally infinite and (more or less) uniformly filled with stars, then, in the absence of absorption, the entire sky would be illuminated with an intensity corresponding to the average surface brightness of the stars, i.e. about that of the Sun.* The fact that this is not the case cannot be explained in terms of interstellar absorption alone, since the absorbed energy would not be lost. In order to eliminate the paradox, however, it is

sufficient to take into account the limited period of time ($<10^{12}$ years) during which stars can maintain their luminosities. The stars would need about 10^{23} years just to 'fill up' the Universe with their light.

50. Opening Doors

The problem of the impact of a bullet on a target (and similar situations, like the collision of snooker balls or a hammer hitting a nail) is a problem where a very large force acts for a very short time. The product of average force and the time it is exerted is called the impulse of the force. When a bullet hits a door, the impulse of the impact is transformed to the deformation of the door. Due to the very short time of collision, the deformation caused by the bullet is spread over a very small area around the point of impact. As such, the bullet makes a small hole. A finger applied to a door creates a force extending over a much longer time. According to Newton's 2nd Law, this produces acceleration which results in door movement rather than door perforation.

51. Red and White Socks

The minimum number of socks I need to select to have a matching pair is three. Two socks might be of different colours. In a set of three socks at least two will certainly match in colour since there are just two colours.

52. Brakes

First the rear brake, then the front one, otherwise the torque created by the force of friction may up-end the bicycle, i.e. the rear wheel moving forward and over the front.

53. Yachts

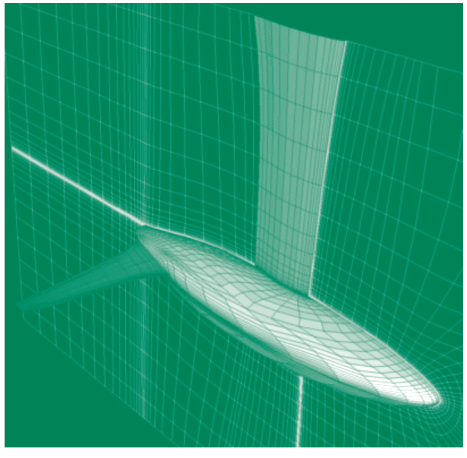
The keel prevents the yacht from turning over under the influence of torque, which is created by the wind interacting with the sails. The keel is also needed for stability while sailing upwind. It prevents the hull slipping sideways through the water. Keels may vary considerably in weight and design, e.g. an America's Cup boat has a 20-ton lead keel bulb that hangs about 4 m beneath the water line (the boat itself can weigh as much as 50 tons).

54. Jumping on the Moon

The centre of gravity of a sportsman is about 1 m above ground. When he jumps a 2-m height, his centre of gravity rises just 1 m from its normal position. On the Moon, this difference (1 m) must be multiplied by 6. As a result, we can expect that the sportsman on the moon will jump 1 m + 6 m = 7 m. In reality it will be even less because the sportsman would need to wear a heavy space suit.

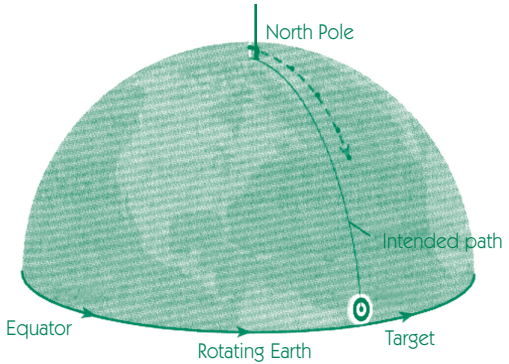
55. Cup of Coffee

The coffee would keep hot for longer in option 1. After adding milk before leaving the kitchen, the temperature of the coffee will be lower than that in option 2 and so will the rate at which the coffee cools.



56. Riverbanks

An object that moves along a north-south path, or longitudinal line, will undergo apparent deflection to the right in the Northern Hemisphere and to the left in the Southern Hemisphere (Coriolis effect). The object does not actually deviate from its path, but it appears to do so because of the motion of the coordinate system (eastward rotation of the Earth). Thus, if a cannon were fired northward from a point on the Equator, the projectile would land to the east of its due north path. This variation would occur because the projectile was moving eastward faster at the Equator than its target further north. Similarly, if the weapon were fired towards the Equator from the North Pole, the projectile would again land to the right of its true path. In this case, the target area would have moved eastward before the shell reached it because of its greater eastward velocity. (See figure on the next page.)



57. Leaf Patterns

Our answer begins with a 13th century mathematician, Fibonacci of Pisa. Fibonacci was educated by Muslims and later published *Liber Abaci* (*The Book of the Abacu*), an historic manuscript that was the principal means of introducing Arabic numerals to the West. This work also contained the following theoretical problem that had long fascinated mathematicians. "If a pair of rabbits is isolated and encouraged to breed, how many pairs of rabbits will be born there in one year, if every month a pair of rabbits produces another pair, and these rabbits begin to bear young two months after their own birth?" Fibonacci's solution to the problem resulted in the following sequence of numbers: 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, 233, with the last one representing the number of rabbit pairs after 12 months.

He recognised that although the series appeared random, it was not so, as each number was the sum of the two preceding numbers. Further, if one divides a Fibonacci number by the one before it, the answer is close to 1.618034. This number is called the golden ratio and is the mathematical basis for the shape of a wide-ranging group of natural and man-made structures: from the Parthenon (one of the most aesthetically pleasing buildings in the world), to sunflowers, mollusc shells (such as *Nautilus*) and leaf arrangements on a plant stem. By following the 'golden ratio' in arrangement, each leaf is able to gain maximum exposure to sunlight.

58. Weightlifting

Yes. There are two reasons why gravity varies. The first is related to one's distance from the Earth's centre: the greater the distance the lesser the effect of gravity. The second reason is due to the Earth's rotation. Near the equator, the velocity is 1600 km/h, so the resulting centrifugal force diminishes the effect of gravity. At the poles, 100 kg would require more effort to lift! The difference in weight (not mass) compared to the equator would be about 1%.

59. Tyres
Treads increase the friction between the tyre and the road. Lateral features make acceleration and braking more effective and also provide a conduit to remove water from between the tyre and road surface (which would decrease friction). Longitudinal features prevent the vehicle from side sliding.

60. The Glass of Water Experiment
When the glass is inverted, atmospheric pressure creates an upwardly directed force sufficient to support the column of water.

61. River Surface
No, otherwise the water would not flow.

62. Iron Ships
As the ship is empty inside, its effective density (mass divided by volume) is less than the density of water.

63. Water Lines
1 – in the river; 2 – in the warm sea; 3 – in the cold sea.

64. Two Balloons
The balloon made of rubber will reach a higher altitude because it will increase in size while getting higher.

65. Balloons on the Moon
No, there is no atmosphere on the Moon. Hydrogen-filled balloons are lighter than air, as such they float. This is not possible when there is no medium in which to float.

66. Missile Protection
When the missile is launched, its velocity is directed in the same direction as the plane, so initially it flies backwards with respect to air, with its tail ahead. The tail stabilizers, which provide stability for the missile, create a force that turns the missile in the direction where the air resistance is minimal (i.e. in the direction of the aircraft). The missile is then likely to destroy the plane.

67. Up and Down
There are numerous answers, including temperature, pressure and humidity.

68. Feather and Lead

They have the same weight – 1 kg.

69. River Flow

Clockwise, as water flows more slowly at the bottom, where frictional forces develop with the mud/sand/stones.

70. Blue Blood?

A vein looks blue because red light travels far enough into the skin to be absorbed by the blood in the vein. If the blood vessel is 0.5 mm (500 microns) below the skin, blue light, which would normally also be absorbed by the vein, reflects out of the skin before reaching the vein. So the light reflecting from tissue over the vein contains less red light than blue, giving the vein a bluish cast. Fair-skinned people look pink and not blue when they blush because small surface capillaries, that become engorged during blushing, lie just about 20 microns below the skin's surface.

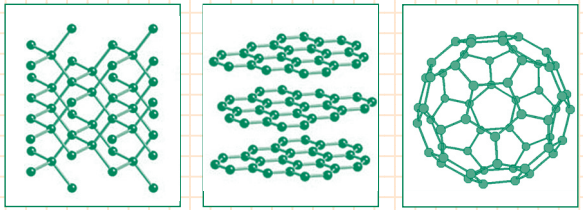
71. Hurricanes

When wind velocity is high, the air pressure is higher above the roof than below. This difference in pressure creates a buoyancy (lift) force, which lifts the roof up.

72. Graphite and Diamond

(a) Very high temperatures and pressures are needed for diamond formation (T > 2000 C, P > 100,000 atm). In nature, these physical conditions exist deep in the Earth's interior. Graphite is formed under lower pressures and temperatures, in the areas that are situated closer to the surface of the Earth and thus more locally abundant.

(b) The crystalline lattice of diamond is more symmetrical than that of graphite. Each carbon atom in diamond is bound to four others in a 3-dimensional network. To change the shape of a diamond, or break it, requires many of these strong bonds to be broken simultaneously. Graphite consists of sheets of strongly bonded hexagonal rings. Each sheet is weakly bound to the one above or below it, and sheets can slide past one another, making graphite a lubricant.

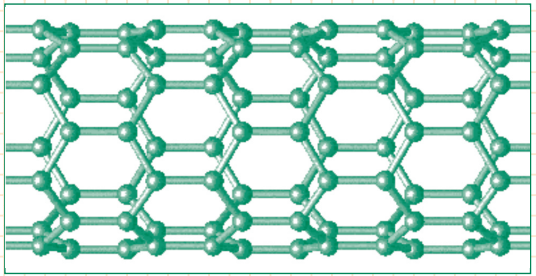


Diamond | Graphite | Fullerene structure or 'Bucky-ball'

Crystalline lattice of diamond and graphite.

(c) The third crystalline form of carbon consists of a unit cell structure called a polyhedron comprising 60-70 carbon atoms in the unit cell. Called Fullerene, it has potential as a superconductor.

Carbon atoms can also be arranged in the form of a cylinder (carbon nanotube). These nanotubes are the strongest man-made fibres known. A single perfect nanotube is about 10 to 100 times stronger than steel per unit weight. (See figure on the next page.)



Nanotube structure

73. Refrigerators

Yes, it will first decrease, then slightly increase. Refrigerators are heat pumps. They remove heat from materials stored in the refrigerator, transferring this to the room. In addition to this, the pump is working and this releases energy along with that transferred from the interior. In such a system, there will be a net increase in the temperature.

74. Lead Roofing

When lead is exposed to air, it darkens and absorbs heat on sunny days. When heated, it expands. If you measure the expansion of the sheet of lead, you will

find that the effects of expansion are greater at the bottom than at the top. This is due to gravity. When the sheet cools at night, the top contracts slightly more than the bottom. Effectively, day-by-day, the whole sheet (the centre of gravity of the sheet) slides down slowly.

75. A Problem in Logic

There are a number of possibilities that you may have arrived at. The following are ones that students often provide:

Caves: The absence of eyes is a characteristic of many species of animals that live all their lives in caves. Eyes, if present, are often degenerate.

Comment: This theory can be falsified as trilobites with eyes are found adjacent to the 'blind' trilobites. The nature of the sediment and the quality of preservation can lead us to conclude that the fossils were not transported and accumulated in an area outside their normal living range.

Sediment burrowers: A sensible suggestion is that the 'blind' trilobite lived beneath the water/sediment interface.

Comment: Again, there is a flaw here, as both types of fossil appear to have been living in the same horizon.

Parasites: A novel suggestion, and one that is very appealing, is that the smaller 'blind' trilobites were parasitic upon the larger trilobites or the eurypterids. Upon death of the host, they may have been dislodged, or perhaps crawled out.

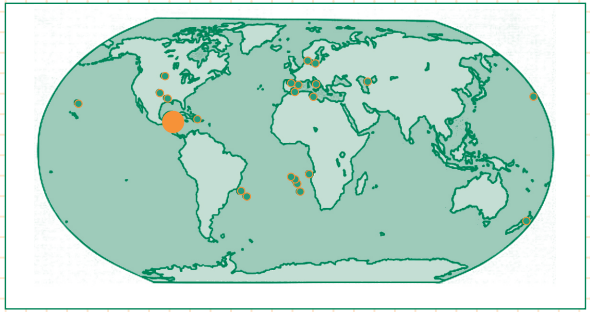
In almost all cases involving palaeontology, we will never be 100% certain as to which answer is the more correct. Logic, however, provides us with pointers.

76. What Happened at the End of the Cretaceous?

The most popular theory is one that was proposed in 1980 by physicist Professor Luis Alvarez. He proposed that the extinctions could be directly attributed to a massive meteorite impact in Mexico, near the Yucatán Peninsula. The supposed site of impact, the Chicxulub Structure (see map), has a characteristic clay layer at the Cretaceous/Tertiary (K/T) boundary. This is found at K/T boundaries throughout the world.

The K/T boundary clay has high levels of iridium and other platinum group elements (PGEs). PGEs are generally very rare in terrestrial rocks but are more common in extraterrestrial rock samples – meteorites, lunar rocks, etc. Alvarez concluded that the K/T boundary clay, with elevated PGE levels, represents a mixture of terrestrial and extraterrestrial rock debris, blown into the atmosphere by the impact event.

A meteorite impact, as envisaged by Alvarez, would have resulted in large amounts of debris being blown into the atmosphere. This would have stayed in the atmosphere for periods of more than a year. The effect of this would severely restrict the amount of sunlight getting to the Earth's surface. Plants would not be able to photosynthesise and would either be eaten or go into a 'winter mode'. The net result is that herbivores (animals that eat only plants) would die, followed quickly by carnivores (animals that eat only meat), leading to mass extinction.



Chicxulub structure, Yucatan Peninsula

Places where rocks of the early Tertiary have elevated iridium levels

77. Balance Scale

No, the lead ball will be lower. Archimedes' principle states that a body immersed in a fluid is buoyed up by a force equal to the weight of the displaced fluid. As the density of lead is higher than the density of glass, the volume of the lead ball is less than the volume of the glass ball (provided they are of the same mass and have no voids inside). Therefore the volume and the weight of the displaced water will be greater in the case of the

glass ball. Hence, the glass ball will be more strongly buoyed up by the Archimedean force than the lead one.

78. Burning Gas

No. Water will not prevent access to oxygen, which is necessary for burning.

79. Ice-Cream

Yes, it will. Actually, it will increase the rate of melting. The ice-cream will melt because it takes energy from warm surrounding air (we assume that you are not eating the ice-cream in frosty conditions!). The air nearest to the ice-cream gets cooler, which slows down melting. However, the breeze from the fan furthers the exchange of cool and warm air, hence speeding up the melting of the ice-cream.

80. Which Eclipse?

It is a lunar eclipse.

81. Dark Moon

Yes, we can, even without direct sunlight. When the Earth passes between the Sun and the Moon and blocks the Sun from shining directly on the Moon, the Moon is still

visible. This is because some sunlight is still hitting the Moon due to the effect of the Earth's atmosphere. Particles in the Earth's atmosphere cause light rays coming from the Sun to refract or bend. As they are redirected through the atmosphere, they move around the Earth and onto the Moon, which is blocked only from direct sunlight. On the journey to the Moon, sunlight passes through the Earth's atmosphere at a shallow angle. The more of the atmosphere that the sunlight travels through, the more the blue and green parts of the spectrum are lost (scattered). That is why the Moon looks red during a lunar eclipse.

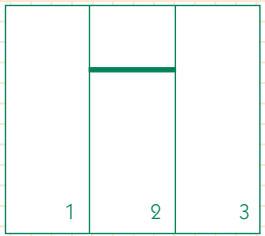
82. Weightless Astronauts

No, the pull of gravity is not particularly weak on the Space Station compared to that on the Earth. It can be expressed in terms of the acceleration of gravity (g), which may be calculated using the formula $g = MG/R^2$, where M is the mass of the Earth, G is the universal constant of gravity, and R is the distance from the centre of the Earth. On the surface of the Earth, R = 6,400 km and, therefore, g = 9.8 m/s/s. For the Space Station, R = 6,800 km (just 400 km from the surface), and g = 8.7 m/s/s. Astronauts who are

orbiting the Earth often experience sensations of weightlessness. The reason for weightlessness is not zero gravity on the orbit. The astronauts are, in fact, in free-fall. Like the falling amusement park rider and the falling elevator rider, the astronauts and their surroundings are falling towards the Earth under the sole influence of gravity. The astronauts (and the Space Station) are falling towards the Earth but without colliding with it. Their tangential velocity allows them to remain in orbital motion while the force of gravity pulls them inwards.

83. The Bookworm

10 cm. The bookworm has eaten the entire second volume. See the diagram.



84. A Sail Boat

No, it only proves curvature of the Earth's surface.

85. The Moon

No. The apparent movement of the Moon in the sky is slower than that of the Sun. (The lunar day-and-night period is about 50 minutes longer than the solar day.) This is why during the lunar month (about 29 days), there is always one day without moonrise (e.g. it starts when the Moon is already above the horizon and finishes when the Moon is still below the horizon).

86. Driving a Car

In this case the area of contact between the tyres and the surface will be larger and therefore pressure on the surface will be less.

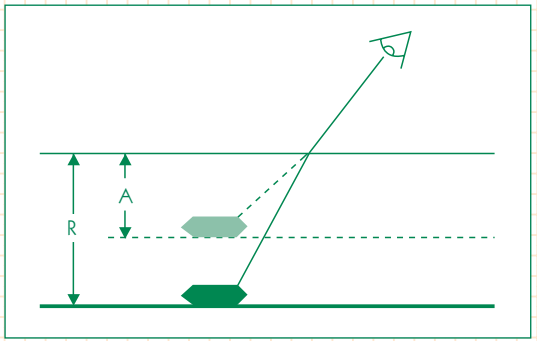
87. Ice and Water

Yes. The mass of the ice is the same as the mass of the water produced after the ice has melted. The volume of the immersed part of ice is the same as the volume of water produced after the ice has melted.

(The density of ice is approximately one tenth of liquid water, such that when floating, 10% of the ice is above the water.)

88. Estimating Depth

When you look in the pool, the depth of the water is much less than in reality. This is called apparent depth. In water the refraction causes the apparent depth (A) to be reduced from the real depth (R). See the diagram below.



89. Water Temperature

The temperature of water is always lower than the temperature of air because of evaporation. Water molecules leave the container and as they do this they take away some energy with them.

90. Melting Ice

Ice starts to melt at zero degrees Centigrade. It takes some time for the temperature in the ice to rise from, say, minus 5 to zero.

91. Ice and Fire

Yes, it is possible on a sunny day. If you make a lens out of a big piece of ice, it will collect solar rays at one point (lens' focal point). The temperature at this point may be high enough to set a flammable material on fire.

92. Just How Safe Is Cola?

Stomach fluids are quite acidic (with a pH range of 1.5 to 3.5). This is much higher than that of cola, which comprises carbonic and phosphoric acids and is only mildly acidic. Thus cola, in moderation, should not harm your stomach. (The effect on teeth is another matter....)

With respect to the coin, the cola acids react with and remove oxides of the alloy, leaving behind a shiny surface.

93. What Makes an Echo?

Sound is propagated (through a medium like air) as waves of compaction and rarefaction. When these waves meet a hard smooth surface, they reflect in a uniform manner. If

the surface is normal to the wave front, we (as the originator of the sound) hear an echo. If the surface is very irregular and made of soft material, the energy of the wave may be absorbed by the material. Under these conditions, sound reflection is generally minor, with sound waves interfering with each other. Thus, no echo is heard. There is a tale that suggests the quack of a duck does not echo. This is untrue, given the conditions outlined above.

94. Why Do We Shiver on Mountaintops?

As gas rises, it expands due to lower pressures. This expansion, however, requires work, and the energy for the work is taken from surrounding air molecules, the resultant being a drop in temperature. This relationship between volume, temperature and pressure of gases is embodied in the Gas Law ($V_1P_1/T_1 = V_2P_2/T_2$, i.e. as volume and pressure decrease, so must temperature). Note, however, that temperatures do increase higher up in the Earth's atmosphere, e.g. in the stratosphere, where they rise above zero. This is, of course, well above any mountain!

95. Opening the Refrigerator...

When you open a refrigerator door, some warm air enters the refrigerator. Upon closing the door, the warm air cools very quickly and forms a partial vacuum. The greater difficulty in opening the door the second time is due to this vacuum. Over a short period, however, air will leak into the refrigerator and the vacuum will gradually decrease.

96. Green Flashes at Sunset

Yes, it does, especially in warmer areas when the air is free of haze and cloud. The green flash is caused by refraction of light by the Earth's atmosphere. Red light is bent less than green, the last image seen being a bright bluish-green flash.

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