HUTCHINSON'S EDUCATIONAL QUIZ BOOKS

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Mathematics for Fun

A QUIZ BOOK

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TO

ALL THOSE WHO

LOVE TO SOLVE

A PROBLEM

CONTENTS

INTRODUCTION

The author and his friend Henry Babb were recently on a long touring holiday in Europe. Whilst they were on this vacation the conversation drifted over to Mathematics and in particular to the secret of success in winning over those who say:

> Multiplication is vexation,
> Division's twice as bad,
> The rule of three perplexes me,
> And fractions drive me mad.

There is no doubt that many children suffer from 'gaps' in their knowledge of Mathematics caused perhaps by insufficient care in the planning of lessons, and this is likely to result in a distaste for and even hostility to Mathematics. The author knows only too well that, in this subject of study more than in any other, there is no short cut, and that the learner must proceed methodically step by step. He believes that there is no necessity for any 'hostility' to Mathematics. Indeed, he thinks that Mathematics can be 'fun', and lead to much joy and satisfaction, provided that the gradient of achievement is properly adjusted to the ability of the individual.

It is certain that in Mathematics nothing succeeds like success. But, of course, some effort is required if anyone is to be moderately successful in the various branches of this subject, just as it is in learning to swim, to dance, or to hit a golf ball six times out of six. When once you are beyond the five-finger exercises in Mathematics, the fun can begin. This has been proved by hundreds of men and women, boys and girls.

The conversation of the author and his friend was, as the last paragraph will suggest, a serious one; but when these two get together their cheerful enthusiasm soon infuses a note of gaiety into the most serious matters. After twenty minutes of hilarious and yet pedagogically serious discussion they agreed that one of the secrets of success in teaching older boys and students is to make lessons and lectures interesting by historical asides and unusual problems. Out of their agreement this quiz book was born. The various sets of questions were quickly drafted and many of the answers were scribbled down without reference to books. The author has had the assistance of friends in other countries who have been able to tap several sources of information unfamiliar to himself.

Perhaps this book will bring to some, whose memories of 'arith', 'alge', 'geom', and 'trig' suggest toil and possibly tears, a different and a happier prospect. The author and his friend have themselves found in this subject an inspiration and a delight—in fact, fun. They say, 'If everybody has to use Mathematics in some form or other, it is only fair that everybody should get some fun out of it.' They hope that the reader will soon be able to join hands with the Major-General and sing from *The Pirates of Penzance*:

> I'm very well acquainted too with matters mathematical,
> I understand equations, both the simple and quadratical,
> About Binomial theorem I'm teeming with a lot of news—
> With many cheerful facts about the square of the hypotenuse.

The author hopes to interest an audience that already has some interest in Mathematics, and to attract an audience that may be stimulated to take an interest. Hence some of the quizzes are a very mixed 'bag', containing questions of much diversity in subject matter and a wide range of difficulty.

The author hopes that he has provided something for everybody.

QUESTIONS

QUIZ NO. 1 *QUITE A LOT OF QUICKIES*

Do these numbers ring a bell? For instance, the number 365 would mean only one thing to me, and that is the number of days in a year. Ask someone to test you with this Quiz. Six seconds for each question. How many can you get right in the time limit of two minutes for all the questions?

1. 1760
2. 2240
3. 4840
4. 640
5. 1·732
6. 5½
7. 22
8. 366
9. ·3010
10. 240
11. ·4771
12. ·4971
13. 14
14. 1·414
15. 1728
16. 21
17. 30¼
18. 62½
19. 90
20. 88

 Answers on page 67

QUIZ NO. 2 *THE PRINTER'S NIGHTMARE*

Before the days of the typewriter the printer's lot was not always a happy one. Imagine how difficult it must have been for the unfortunate printer trying to set up the type for an arithmetic book when the hand-written manuscript was illegible. One printer overcame this difficulty by putting 'stars' for the figures he could not decipher. See if you could have helped him by finding out what the figures really are.

1. Addition:

```
 *22*
 1**1
 ————
 3489
 ————
```

```
  113
  6*4
  14*
  *26
 ————
 *410
 ————
```

2. Subtraction:

```
 4**2
 *35*
 ————
  121
 ————
```

```
 6*35
 *82*
 ————
  4*7
 ————
```

3. Multiplication:

```
  *7
  **
 ———
 **5
 ***
 ————
 **91
 ————
```

```
    ***7
     ***
    ————
  *37**
  **203
 ****6
 ———————
 *******
 ———————
```

4. Equations:

$5x - 5 = \star x - 3$

$\therefore x = 2$

$x^2 - 4x = \star$

$\therefore x = 7$ or $\star$

Answers on page 68

QUIZ NO. 3 'SPEEDO'

There are many recognized mathematical symbols. You will know nearly all of them, but it is interesting to know who introduced them. We take so much for granted these days, and it is only when we stop to think that we appreciate much we so often dismiss as commonplace. So when you so readily answer the questions asked here, try to name the person who introduced the symbol you give for each answer. (This cannot be done in every case.) What is the mathematical symbol for . . . . ?

1. equals
2. multiplied by
3. square root of
4. varies as
5. greater than
6. infinity
7. 'as', in 'a is to b as c is to d'
8. the number of combinations of n things taken r at a time
9. the ratio of the circumference to the diameter for any circle
10. a times a times a

 Answers on pages 69–70

QUIZ NO. 4 *SIMPLE—PERHAPS!*

Can you solve these problems?

1. If 5 girls pack 5 boxes of flowers in 5 minutes, how many girls are required to pack 50 boxes in 50 minutes?

2. A boy has a long card strip 1″ wide and 48″ long. It is marked at 1″ intervals so that he can cut off a series of square inches. If the boy takes one second for each cut, how long will it take to cut the 48 square inches?

3. To move a safe two cylindrical steel bars of diameter 7 inches are used as rollers. How far will the safe have moved forward when the rollers have made one revolution?

4. In an Indian town of 20,000 people, 5% of them are one-legged, and half the others go barefoot. How many sandals are worn in the town?

5. Without introducing + signs, arrange six 'nines' in such a way that they add up to 100.

6. What is peculiar about the L.H.S. of $50\frac{1}{2} + 49\frac{38}{76} = 100$?

7. A fish had a tail as long as its head plus a quarter the length of its body. Its body was three-quarters of its total length. Its head was 4 inches long. What was the length of the fish?

 Answers on pages 71–73

QUIZ NO. 5 ARE YOU AT HOME IN ROME?

For most of the answers to this Quiz you will have to know the Roman figures. As they had no zero to give their numbers a 'place value', it must have been more than a little awkward when it came to multiplication!

1. What aid was used by the Romans to help with calculations?

2. The following is cut on a London monument: MDCLXVI. What year does this represent?

3. Write 1789 in Roman figures.

4. What is the largest number you can write using these Roman numerals once each, I,C,X,V,L?

5. What is the smallest number you can write using the same Roman numerals once each, I,C,X,V,L?

6. Without changing to our Hindu-Arabic notation find the value of CXVI + XIII + VI + CCLXV.

7. What Roman numbers of two integers between one and twenty become larger when the left-hand integer is omitted?

8. Was a 'groma' used by the Roman merchant, surveyor, cook, or sailor?

 Answers on pages 74–75

QUIZ NO. 6 *EASY TEASERS*

1. During a holiday it rained on 13 days, but when it rained in the morning the afternoon was fine, and every rainy afternoon was preceded by a fine morning. There were 11 fine mornings and 12 fine afternoons. How long was the holiday?

2. At what time between 7 and 8 o'clock will the two hands of a clock be in a straight line?

3. If $11^3 = 1331$ and $12^3 = 1728$ what is the cube root of the perfect cube 1442897?

4. A bottle of cider costs 24 pence. The cider cost 12 pence more than the bottle. How much should you receive on returning the bottle?

5. The lengths of the sides of a right-angled triangle measure an exact number of feet. If the hypotenuse is 1 foot longer than the base and the perpendicular is 9 feet long, how long are the sides?

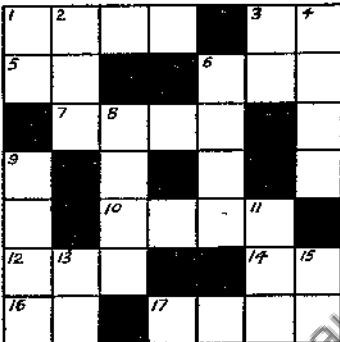
6. A spruce tree when planted was 3 feet high and it grew by an equal number of feet each year. At the end of the seventh year it was one-ninth taller than at the end of the sixth year. How tall was the tree at the end of the twelfth year?

7. Without doing the actual division state whether 13972536 is exactly divisible by 8.

8. A cement mixture costs £11 a ton. It is composed of grade A cement at £12 a ton and grade B cement at £8 a ton. How were these two cements mixed?

 Answers on pages 76–78

QUIZ NO. 7 *CROSSFIGURE*



ACROSS

1. The number of cubic inches in 1 cubic foot.
3. The number of yards in $1\frac{1}{2}$ chains.
5. The arithmetic mean of 2 and 50.
6. The value of 'g' in cm. per sec. per sec.
7. The number of feet in 1 mile.
10. The simple interest on £18,900 for 4 years at $2\frac{1}{4}\%$.
12. The number of ways in which 4 boys and 4 girls can sit at a round table so that no two boys sit together.
14. The angle subtended at the centre by the side of a regular octagon inscribed in a circle.
16. The diagonal of a rectangular plot 20 yards long and 15 yards wide.
17. The sixth term of the series 6, 18, 54, ——.

DOWN

1. The number of sides in a duodecagon.
2. 1122 ft. per sec. expressed in m.p.h.
3. The size of an angle opposite an angle of 142° in a cyclic quadrilateral.
4. The value of π, correct to 3 places of decimals, multiplied by 1000.
6. The smallest number divisible by 11 and greater than 9,000.
8. The area to the nearest square foot of a circular track, of width 10 feet and inner circumference 250 feet. ($\pi = 3\frac{1}{7}$.)
9. The third leap-year in the 19th century.
11. The bearing understood by an air navigator equivalent to the sailor's direction N.E.
13. The angle which the graph of $y = x$ makes with the x — axis.
15. The length of the hypotenuse of a 30°, 60°, 90° triangle if the side opposite the 30° is 29 feet.

 Answers on pages 79–80

QUIZ NO. 8 *THE TRIANGLE TEST*

A triangle is a geometrical figure bounded by three straight lines and having three angles. Such a definition may be correct, but it gives one the idea that a triangle is a decidedly uninteresting figure. There are many different kinds of triangles and each one has its own interesting peculiarities. From the information given can you state the names of these triangles?

1. I surmount the traffic signs which warn, and I am painted red.

2. I appear when a man stands on level ground with his legs straight and his feet slightly apart.

3. I have a special name derived from a Greek word meaning 'uneven'.

4. I am formed by joining the feet of the perpendiculars from the vertices of a triangle to the opposite sides.

5. The sum of the squares on two of my sides equals the square constructed on my third side.

6. There are at least two of us. We find that our corresponding angles are equal and our sides are proportional.

7. The sides and the diagonals of a quadrilateral are used to construct me.

8. My sides are not straight lines and the sum of my angles is greater than 180°.

9. I have gained the title 'Pons Asinorum' for a certain proposition in Euclid.

10. I am readily suggested when you look at a laburnum leaf.

 Answers on pages 81–82

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QUIZ NO. 9 *POUR LES JEUNES*

1. Un café et deux gâteaux valent 100 francs. Deux cafés et deux gâteaux valent 140 francs. Calculez le prix de chacun d'eux.

2. Pensez-vous qu'il soit possible de partager en trois parties égales un angle donné en utilisant seulement la règle et le compas?

3. Comment appelle-t-on une démonstration où l'on imagine que l'on place un angle ou une courbe sur un autre angle ou une autre courbe?

4. Est-il possible de trouver, par construction géométrique (avec règle et compas) des valeurs approchées de $\sqrt{2}$, $\sqrt{3}$, $\sqrt{4}$, etc.?

5. Dans la définition des rapports trigonométriques sin et cos, l'hypotenuse d'un triangle rectangle figure au dénominateur. Quelle est la valeur maxima de ces rapports?

6. Donnez des exemples d'éléments géométriques (1) sans dimensions, (2) à une dimension, (3) à deux dimensions, (4) à trois dimensions.

7. Comment appelle-t-on un raisonnement par lequel on montre qu'une proposition ne peut pas ne pas être vraie?

8. Comment s'appelle le raisonnement qui consiste à supposer qu'une ligne, un cercle etc. tourne autour d'un axe?

 Answers on pages 83–84

QUIZ NO. 10 *WHO CAN IT BE?*

In this Quiz you will find ten anagrams. Each question is an anagram of the name of a well-known mathematician. To help you, a sentence is added which refers to the person named in the anagram.

1. DIME—SEARCH. 'If I had a fulcrum I could move the world.'

2. SCARED SET. He did not belong to this set, for he was a soldier before he was attracted to mathematics.

3. MENU SALE. He was one of the few of the first century A.D. who did original mathematical work of any ability.

4. A DACRON. He could not have 'obtained' a dacron shirt, but he seems to have 'acquired' a contemporary's solution of a cubic equation.

5. PANIER. He was not a Frenchman, and his 'bones' were not kept in a basket.

6. WAS ILL. He had much to do with the founding of the Royal Society.

7. RED TOUGH. Yet he was delighted to hear of the King's return, and even invented a 'rule'.

8. ALL PACE. He discovered a famous differential equation.

9. RULE E. A Swiss mathematician, and a certain constant has been given his name.

10. ROME DIVE. He was chosen to decide the controversy over the discovery of the calculus.

 Answers on pages 85–87

QUIZ NO. 11 *TEASERS*

1. There are three books each one inch thick. They stand side by side in order—Volume I, II and III. A bookworm starts outside the front cover of Volume I and eats its way through to the outside of the back cover of Volume III. If the worm travels in a straight line how far does it travel?

2. A man built a cubical house with ordinary windows in all the upright walls. He found whenever he looked out of a window that he was looking south. Where did he build his house?

3. A merchant has two large barrels. The smaller barrel holds 336 litres but is only $\frac{5}{8}$ths full of wine. He empties this wine into the other barrel and finds that the wine fills only $\frac{4}{9}$ths of it. How much wine would the larger barrel hold when full?

4. What three curves are produced by making sections of a right circular cone in directions other than parallel to the base?

5. Two men play a card game and the stake is one penny a game. At the end one has won three games and the other has won three pennies. How many games did they play?

6. A number consists of three digits, 9, 5, and another. If these digits are reversed and then subtracted from the original number an answer will be obtained consisting of the same digits arranged in a different order still. What is that other digit?

 Answers on pages 88–89

QUIZ NO. 12 DON'T RUN ROUND IN THESE!

There are many interesting things to know about circles. One or two of these may make you think!

1. Complete the following verse:
   'Tweedledum and Tweedledee
   Around the circle is π times ____.
   But if the area is declared
   Think of the formula ____.'

2. What two words derived from the Latin for 'a bow' and 'a string' are used in the geometry of the circle?

3. What is meant by 'squaring the circle'?

4. What important ratio was known until 1736 as 'c' or 'p'?

5. The minute hand of a clock is 7 inches long. What distance does the tip of the hand move in 22 minutes?

6. What path is traced out by a mark on the tyre of a bicycle wheel as the cycle is ridden in a straight line on a level surface?

7. In reference to question 6 what distance does this mark actually move through as the wheel revolves once?

8. Construct semi-circles on the three sides of an isosceles right-angled triangle. You will form two lunes. Show that each lune equals half the area of the triangle.

 Answers on pages 90–91

QUIZ NO. 13 *SOME OLD AND SOME NEW*

1. Find a quantity such that the sum of it and one seventh of it shall equal nineteen.

2. How many guests were present at a Chinese party if every two used a dish for rice between them, every three a dish for broth, every four a dish for meat, and there were 65 dishes altogether.

3. A retired Colonel Blimp lived a quarter of his life as a boy, one-fifth as a young man, one-third as a man with responsibilities, and thirteen years on pension. How old was he when he died?

4. A club's opening bat named Ruck,
Squared his number of runs for luck,
After subtracting his score,
He took off seventy-two more,
And the final result was a 'duck'.

How many runs did Ruck make?

5. Some freshers from a nameless Hall,
Played hockey with a lightish ball,
They found twice times its weight,
Plus weight squared, minus eight,
Gave 'nothing' in ounces at all.

What was the weight of the ball?

6. A cathedral tower 200 ft. high is 250 ft. from a church tower 150 ft. high. On the top of each tower is a pigeon. The two pigeons fly off at the same time and at the same speed direct to some grain on the level straight road between the towers. The pigeons reach the grain at the same instant. How far is the grain from the foot of the cathedral tower?

 Answers on pages 92–93

QUIZ NO. 14 *SEE AND PERCEIVE*

Lots of people see things every day and yet they don't see them. Because things are familiar they often go unnoticed. Do you know how many stairs you climb to the first floor in your house? Can you state what particular geometrical shape is associated with . . . ?

1. the cell in a honeycomb?
2. a roof truss or a braced shelf-bracket?
3. a Norman arch in church architecture?
4. an open pantograph?
5. the present-day threepenny piece?
6. the cross-section of the stem of a plant of the Labiatae family?
7. the join of the outermost tips of the corolla of a campanula?
8. a 'diamond' on a playing card?
9. the constellation Pegasus?
10. the three stars Betelgeuse, Sirius, and Procyon?

 Answers on pages 94–95

QUIZ NO. 15 *WHY MAKE IT A DIFFICULTY?*

It is really most interesting to read about our system of weights and measures, but any detached onlooker must be highly amused at the way we tenaciously make things difficult for ourselves. Why do we not adopt the metric system? Is there an answer to this stupidity? Shall we continue to torture ourselves for ever? Do you know . . . ?

1. the name of the Roman pound?

2. the Latin word meaning 'a twelfth part'?

3. where the Troy of Troy weight is situated, or is it the name of a man?

4. the measure of weight used to weigh diamonds?

5. the body measurement now standardized as four inches?

6. what unit is derived from the Latin word meaning 'a field'?

7. what other name is given to a rod or perch?

8. the name given to the 24th part of an ounce by a pharmaceutical chemist?

9. the King who is supposed to be connected with our standard measurement of a yard?

10. a particular 'weight' that is true to its name in the United States of America and not in Great Britain?

 Answers on pages 96–97

QUIZ NO. 16 *SPOT THE MISTAKES*

Merely because a statement appears in print it is not necessarily accurate! How often one hears the remark, 'I'll show it to you in black and white', as if that is sufficient to decide whether something is true. A mathematician must always be accurate. Are the following statements true or false?

1. The pentagram of Pythagoras is formed by drawing all the diagonals of a regular pentagon.

2. Archimedes was the originator of the well-known puzzle of Achilles and the tortoise.

3. 1.5 p.m. is sometimes written as 1305 hours.

4. The curve in which a uniform cable hangs when suspended from two fixed points is a parabola.

5. A pantograph is a mechanical device for drawing figures similar to given figures.

6. A histogram is a hundred kilograms, and this standard unit is kept at the International Bureau of Weights and Measures at Sèvres, near Paris.

7. A cantilever beam is a beam supported at one end only and extending horizontally.

8. A parameter is an independent variable in terms of which the co-ordinates of a variable point may be expressed.

 Answers on pages 98–100

QUIZ NO. 17 *WHAT IS MY LINE?*

For purposes of identification certain lines have been given special names, e.g. a tangent, an arc, and a radius. You have to name the line referred to in each of these questions. I . . .

1. join the vertex of a triangle to the mid-point of the opposite side.
2. was said to be the shortest distance between two points.
3. subtend a right angle at the circumference of a circle.
4. am the line so drawn in a circle that the angle between me and a certain tangent is equal to the angle in the alternate segment.
5. 'touch' a hyperbola at an infinite distance.
6. cut a circle in two points.
7. join all the points of the same latitude on the earth.
8. am the locus of a point from which the tangents drawn to two given circles are equal.
9. am the essential straight line which together with the special point or focus enables points on an ellipse or parabola to be determined.
10. pass through the feet of the perpendiculars drawn to the three sides of a triangle from any point on the circumcircle of the triangle.

 Answers on pages 101–102

QUIZ NO. 18 *LIKE BUT UNLIKE*

There is a suffix -oid which is usually found at the end of Greek roots. This suffix means 'having the form of', 'like' or 'resembling'. For instance, the earth is said to be an oblate spheroid, which means that it is like a sphere which is flattened (oblate) at the poles. In mathematics you will sometimes find a word ending in -oid, and in this quiz you have to give a one-word answer using this suffix.

1. The surface made by revolving a parabola about its principal axis.

2. Like the surface of a perfect rugger ball.

3. The medians of a triangle have this point in common.

4. The curve traced out by a mark on the edge of a sixpenny piece when rolled round the inside edge of a fixed tea-cup or a cylindrical can.

5. The curve traced out by a mark on the edge of a sixpenny piece when rolled round the edge of a fixed penny.

6. It is an 'ivy-shaped' curve and was discovered by Diocles.

 Answers on pages 103–104

QUIZ NO. 19 *A MATHEMATICAL MIXTURE*

This is a mixed bag of questions. Some are easy and some are hard. There is no connection between them whatsoever. Get busy like the proverbial bee and count how many you can answer correctly. Full marks will qualify you for the award of the pythagorian star which you can draw for yourself. Do you know . . . ?

1. the number of barleycorns in an inch?

2. the instrument used by Sir Francis Drake to find the altitude of the sun and hence the time?

3. the instrument used in the 16th century to tell the time at night by observing the constellation Ursa Major?

4. the name of the mathematician who first proved

$$\triangle = \sqrt{s(s-a)(s-b)(s-c)}?$$

5. the name given to the figure like a five-pointed star often used in the Middle Ages to frighten away witches?

6. what 'meter' is used to measure the area contained by a closed plane curve?

7. the name of the solid formed by cutting a pyramid or a cone by two parallel planes?

8. to what use Simpson's rule is put?

9. the common name for a regular hexahedron?

10. how long a clock will take to strike 'twelve' if it takes five seconds to strike 'six'?

 Answers on pages 105–106

QUIZ NO. 20 FIND THE GENTLEMAN

In the following sentences will be found one, two, or three words that form the anagram of the name of a mathematician.

1. Those attending his classes were either 'listeners' or 'mathematicians' and the former must have trod a gorsy path.
2. He formed a school called the 'Academy' where his students seemed to lap around him.
3. 'Number work cannot be taught by the rod alone' is a fact recognized by all teachers since 'he' introduced Arabic numerals into Europe.
4. He observed a swinging lamp and was not interested in whether a gel oil was a contradiction in terms.
5. There is no doubt that many a clasp went into the construction of the arithmetical machine which he invented.
6. Men like him would rob war of its sting, for he recognized and frankly acknowledged the superiority of his pupil.
7. Some of his ideas are not new, but there is no doubt that he was without equal.
8. The geometrical interpretation of complex numbers on a blackboard can be rubbed off with a rag and some 'elbow grease'!

 Answers on pages 107–109

QUIZ NO. 21

PECULIAR STANDARDS AND MEASURES

Peculiar indeed! Who ever thought of buying an antiquarian and being presented with a sheet of paper? Many queer names are given to units and standards. These are well known in the various trades but sound strange to the man in the street. Can you answer these questions?

1. What is the standard measurement of the speed of ships?

2. What do you want if you are purchasing a 'Double Elephant'?

3. An order is being made out for 1000 Duchesses. What is being ordered?

4. What is sold by the Leningrad standard hundred?

5. A cran of them would be too much for one household. What is sold by the cran?

6. What is required when a salesman is asked for 6 casts of 48?

7. 'I have just bought a "cord", so we should have enough.' What shall we have enough of?

8. What is paid for by the therm?

9. Name the measure of wine which is 252 gallons.

10. What is sold by the Kilowatt-hour or Unit?

 Answers on pages 110–111

QUIZ NO. 22 *BREVITY IN MATHEMATICS*

The mathematician frequently uses abbreviations in his work. For the word 'logarithms' he uses the shortened term 'logs', and for 'Simple Harmonic Motion' he uses the initial letters of these words and writes 'S.H.M.' What abbreviation does he use for . . . ?

1. 'which was to be proved or demonstrated'?

2. the cosine of the angle θ?

3. an expression which depends for its value on the value you give to x?

4. the integration of $16x^3$ with respect to x?

5. the smallest number which is exactly divisible by two or more numbers?

6. the hyperbolic sine of x?

7. the square root of -1?

8. the greatest number which will divide exactly into two or more numbers?

9. the derivative of y with respect to x?

10. the eccentricity of conics?

 Answers on pages 112–113

QUIZ NO. 23 'NAMES'

It is always good fun discovering the derivation of a word. There is no doubt that even a little acquaintance with Latin and Greek enables one to appreciate why some subjects or figures are named as they are. You are not given in this Quiz the Greek, Latin, or Arabic 'source-words' but translations of them. You have to state what the resulting word is in English. Most of the answers will consist of mathematical words that are nouns and most of these will be the names of various branches of mathematics. The derivation is from . . .

1. two Greek words, meaning 'a star' and 'to arrange'.
2. a Greek word, meaning 'the art of counting'.
3. three Greek words, suggesting 'the measurement of a triangle'.
4. two Greek words, meaning 'the earth' and 'to measure'.
5. the title of an Arabic book. Various translations of which are possible; 'the reunion of broken parts' is the simplest.
6. a Greek word that may be expressed as 'relating to learning'.
7. the Greek meaning of 'causing to stop or stand'.
8. a Latin word, meaning 'a little stone'.

 Answers on pages 114–115

QUIZ NO. 24 THINGS ANCIENT AND MODERN

Necessity is said to be the mother of invention. This is certainly true as far as the instruments and apparatus of mathematics are concerned. All of you will know something about the instruments whose names are required as answers to the following. Name the instrument . . .

1. known in your nursery days as a bead frame.
2. called for simplicity 'a water clock'.
3. used in the Middle Ages to keep accounts, and looking like a notched piece of wood.
4. made of thin wood (or perspex) with edges shaped to help curve drawing.
5. used on board ship for astronomical observations.
6. handy for surveying and measures angles in a vertical and horizontal plane.
7. which when first invented, utilized two Gunter's Scales.
8. invented by Blaise Pascal, and is now a boon to many clerks.
9. which might also be an apt description of a very senior schoolmaster when everything has gone wrong.
10. employed to measure the thickness of a wire to within 0·001 cm.

 Answers on pages 116–117

QUIZ NO. 25 *A MATHS MINCE-PIE*

1. What is the name of the small metal frame with a glass or perspex front on which is a fine black line? It is used to facilitate the reading of a slide rule.

2. What is constructed in the same ratio as the following numbers? 24 : 27 : 30 : 32 : 36 : 40 : 45 : 48.

3. Two half-crowns, H and C, are touching one another. H is rolled round C without slipping. How many times will H revolve around its own centre by the time it is back in its original position?

4. What curve has been called the 'Helen of Geometers'?

5. How can you plant ten tulips in ten straight rows with three tulips in each row?

6. The diameter of a gramophone record is 12 inches. The unused centre has a diameter of 4 inches and there is a smooth outer edge of width 1 inch around the recording. If there are 91 grooves to the inch, how far does the needle move during the actual playing of the recording?

7. Two men, Mr. Henry and Mr. Phillips, are appointed to similar posts. One elects to receive a commencing salary of £1000 per annum with increments of £200 each year, and the second, Mr. Phillips, chooses a commencing salary of £500 per half-year and an increase of £100 every six months. Which person is the better paid?

 Answers on pages 118–119

QUIZ NO. 26 'C' CARRIES THE CAN

Below you will find some problems which were common in arithmetic textbooks 50 years ago. So often Mr. A, Mr. B, and Mr. C appeared and the unfortunate Mr. C seemed to be the back-marker, the loser, or the person who 'carried the can'! If ever a single person deserves lasting credit from authors it is surely Mr. C. There are no rivals for that honour! Turn the clock back 50 years and solve the following:

1. A field is owned by three people; A has $\frac{3}{5}$ of it, and B has twice as much as C. What fraction of the field belongs to C?

2. In a mile race A beats B by 20 yards, and he beats C by 40 yards. By how much could B beat C in a mile race?

3. A and B can do a piece of work in 10 days; A and C can do it in 12 days; B and C can do it in 20 days. How long will C take to do the work alone?

4. During a game of billiards A can give B 10 points in 50, and B can give C 10 points in 50. How many points in 50 can A give C to make an even game?

5. A, B, and C form a partnership. A furnishes £1875, B furnishes £1500, and C £1250 capital. The partnership makes a profit of £1850 in the first year. What should C take as his share of the profit?

6. Pipes A and B can fill a cistern in 2 hours and 3 hours respectively. Pipe C can empty it in 5 hours. If all be turned on when the cistern is empty, how long will it take to fill?

 Answers on pages 120–121

QUIZ NO. 27 *LETTERS FOR NUMERALS*

Some simple sums were prepared using the numerals 0 to 9. Then all the numerals were changed to letters. You have to discover the code which was used for the change. You can do this if you look carefully for every possible clue. There is no need to guess. Work these clues methodically, trying each possibility one after the other. There is only one solution to each sum. The code has been changed for each sum. Don't peep at the answers until you have finished and checked your calculation because the knowledge of one single change will make it too easy and spoil your fun.

1. Addition

```
  XXXX
  YYYY
  ZZZZ
 -----
 YXXXZ
 -----
```

3. Division

```
IL)PHIL(HIL
   IL
   --
    TI
    LS
    --
    HIL
    HIL
    ---
    ...
```


2. Multiplication

```
  PNX
   NX
  ---
  NXS
 RNX
 ----
 ZPNX
 ----
```

4. Division

```
AY)NELLY(YFY
   NLY
   ---
    PPL
    PNH
    ---
     NLY
     NLY
     ---
     ...
```

 Answers on pages 122–124

QUIZ NO. 28 *WHO COULD HAVE THIS ON HIS FAMILY SHIELD?*

The coats of arms of towns, cities, and families all obey certain well-defined laws of heraldry. Sometimes these shields are divided into two, and sometimes into four, sections. On the family shield belonging to Sir Isaac Newton there might be an apple tree in one section and a spectrum in another. If a mathematician is noted for some special achievement it would be reasonable to include something connected with this on his family shield. Who might have the following on theirs?

1. A mural quadrant.
2. The Great Pyramid and its shadow.
3. A sphere inside a cylinder.
4. Rectangular axes marked XOX′ and YOY′.
5. A cyclic quadrilateral with the two diagonals drawn.
6. A surveyor's chain with 66 feet marked above it.
7. An ellipse with the sun at one focus.
8. The leaning tower of Pisa.

 Answers on pages 125–127

QUIZ NO. 29 *ARCHES*

The application of geometry to architectural drawings is obvious and a mathematician can be an interesting companion on a sight-seeing tour. One thrilled a group of schoolboys when he showed them how a particular arch in an old church could be drawn readily with the aid of a pair of compasses and a ruler. Can you spot the arch which is suggested by the following statements?

1. It sounds like an American exclamation, but is an arch of two double curves which rise to a point.
2. It is not connected with a medical journal, but is common in 'Early English' churches.
3. Very good food is suggested! The Mohammedan race inhabitating North-West Africa never used this arch.
4. This arch is not connected with heraldry, but is used to support a flight of solid steps.
5. Obviously very much connected with a certain kind of triangle.
6. The commonest brick arch in house construction.
7. A rounded arch of more than a semi-circle.
8. Most likely to be found in spacious buildings constructed in England between 1485 and 1546.
9. I am semi-circular in shape and often have a chevron ornamentation.

 Answers on pages 128–130

QUIZ NO. 30 *NAME THE TOWN*

The answer to each question in this Quiz may be expressed as a single letter of the alphabet. Rearrange these letters to form the name of a well-known town.

1. Is the initial letter of a line which touches a circle.

2. Counting through the alphabet thus: 1 = a, 2 = b, 3 = c, etc., this letter represents a score.

3. The answer to 0 times 123 looks like this.

4. The eighth term of the series 21, 18, 15, 12, ... looks like this.

5. In trigonometry 'it' equals $\dfrac{a + b + c}{2}$.

6. The abbreviation for the standard unit of length in the metric system.

7. The initial letter of the mathematician whose name has been given to a well-known theorem concerning right-angled triangles.

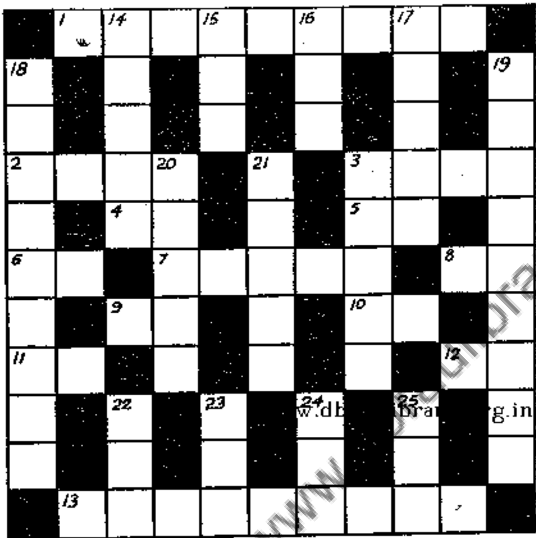
8. The second letter of the name given to an equation of the type $ax^2 + bx + c = 0$.

9. Simple interest equals $\dfrac{P \times ? \times T}{100}$.

10. The area of a triangle equals $\frac{1}{2}$ B $\times$?.

 Answers on page 131

QUIZ NO. 31 *DON'T GET CROSS WITH THIS!*



ACROSS

1. He is otherwise known as Leonardo of Pisa.
2. Pascal found work on the cycloid to be a —— for toothache.
3. Half of brackets.
4. Take nothing from you.
5. To do a problem in reverse would be strange. (Curtailed.)
6. The abbreviation for an Indian coin.
7. A severely beheaded astronomer of the 17th century.
8. A surprising degree for a mathematician at Cambridge.
9. It is, that is, ——.
10. The abbreviation for a British weight.
11. The initials for the author of *The Whetstone of Witte*.
12. The abbreviation for 1000 grams.
13. Il définit les lois des leviers et du centre de gravité des corps.

DOWN

3. He wrote *Finite Differences*.
14. His name suggests 'tusks'.
15. Integers not divisible by 2.
16. A part of a curve.
17. The straight line joining two points on a curve.
18. An able Scottish mathematician of the 18th century.
19. A quadrilateral whose angles are all right angles.
20. An able Swiss mathematician of the 18th century.
21. Cricket scores were often kept on these sticks.
22. Isaac Newton's title.
23. How motor-car speeds are measured in Britain.
24. Many mathematicians knew this river during their University days.
25. Colloquially this is 'dough', but abbreviated it is good English.

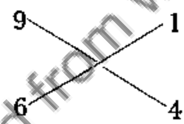
 Answers on pages 132–134

QUIZ NO. 32 *BROWSING IN BOOKS*

It is always interesting to look at old books. The Duke Humphrey's Library in the Bodleian Library at Oxford displays countless objects of interest in some of its glass cases. At Oxford, Cambridge, and London many old books concerning mathematics can be seen. You may have been fortunate enough to have seen some of the following in old arithmetic books. What could the author have meant by . . . ?

1. $56\dot{7}34\dot{2}452$

2. $9\dot{8}5\dot{2}5\dot{4}76$

3. 

4. $364 \,\big|\, 8$

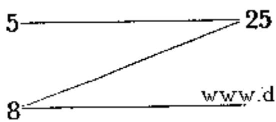
5. $$\begin{array}{ccc} & 4 & \\ \frac{1}{3} & \text{by} & \frac{3}{4} \\ & 9 & \end{array}$$

6. $83\ 4'\ 2''\ 5'''$

7.

3 feet	8 inches	
5 feet	4 inches	
18	4	
1	2	8
19 feet	6	$\frac{2}{3}$ inches

8.



 Answers on pages 135–136

QUIZ NO. 33 *WHAT SIZE DO YOU NEED?*

'Light she was, and like a fairy
And her shoes were number nine,'

What was the length of Clementine's foot? The more complicated community life becomes, the greater the need for standards and sizes in measurements. Today each business, trade, and industry has its special terms. How many of these do you know?

1. Is a 30 line button larger than a 60 line button?

2. Is a number 50 cotton thread thicker than a number 24 cotton thread?

3. If a man's 'size 1' shoe is $8\frac{2}{3}$ inches long, what is the length of a 'size 10' shoe?

4. A shirt may have a 15-inch collar and the same size shirt may have a number 38 marked on it. What does the number 38 refer to?

5. Are American and English sizes in hats the same?

6. A 'numbered size' is printed as well as the length on the label of a box of wood screws. What does this 'numbered size' actually refer to?

7. Is a 'size 16' knitting needle twice as thick as a 'size 8' knitting needle?

8. What unit is employed to describe the fibres in nylon stockings?

 Answers on pages 137–139

QUIZ NO. 34 *NUMBER KNOWLEDGE WITH A DIFFERENCE*

We hope that when you have finished this Quiz you 'have not lisp'd in numbers, but the numbers came'! What is the number of the . . . ?

1. wonders in the ancient world?
2. graces in classical mythology?
3. kings in a French pack of cards?
4. beast as given in the New Testament?
5. muses in Greek mythology?
6. gentlemen of Verona?
7. elements in the teaching of Aristotle?

What is 'x' in the following quotations?

8. 'Alone and warming her "x" wits
   The white owl in the belfry sits.'
9. '"x" days, sire, have elapsed since the fatal moment when Your Majesty was forced to quit your capital.'
   (The capital is Paris.)
10. 'Il faut tourner "x" fois sa langue dans sa bouche avant de parler.'

 Answers on pages 140–141

QUIZ NO. 35 *WHY BE ANTI-LOGS?*

On the whole logarithms have been most useful to those who can add, subtract, and look up tables. They were undoubtedly invented to shorten arithmetical calculations. No tables are needed to answer these questions.

1. Give the meaning of the two Greek words from which the word logarithm is derived.

2. What is the logarithm of 16 to the base 4?

3. Were logarithms invented before the time of Newton?

4. Name the two mathematicians who were the cause of an argument between a Swiss and a Scotsman as to who invented logarithms.

5. Who gave us the common logarithms?

6. What nationality was the mathematician who calculated most of the table of common logarithms first published in 1628?

7. Who wrote the *Descriptio?*

8. How can natural logarithms be converted to common logarithms?

9. What useful mathematical instrument is constructed by making use of logarithms?

10. Which is the greatest and which the least of log $(2 + 4)$, $(\log 2 + \log 4)$, $\log (6 - 3)$, and $(\log 6 - \log 3)$?

 Answers on pages 142–144

QUIZ NO. 36 WAS WILLIE WANGLING?

Some rather surprising correct results are often found in Willie's work, which, like the 'curate's egg', is only good in parts. Here you are given some examples from Willie's homework. You have to correct these as quickly as possible. Are they right or wrong?

1. $12^2 = 144 \quad \therefore 21^2 = 441$

2. $13^2 = 169 \quad \therefore 31^2 = 961$

3. $\sqrt{5\frac{5}{24}} = 5\sqrt{\frac{5}{24}}$

4. $\sqrt[3]{2\frac{2}{7}} = 2\sqrt[3]{\frac{2}{7}}$

5. The lines joining the mid-points of the sides of a parallelogram form a parallelogram. Therefore the lines joining the mid-points of the sides of any convex quadrilateral also form a parallelogram.

6. $\text{Sin}\,(a + b)\,.\,\text{Sin}\,(a - b) = (\text{Sin}\,a + \text{Sin}\,b)(\text{Sin}\,a - \text{Sin}\,b)$

   $\therefore \text{Sin}\,(a + b)\,.\,\text{Sin}\,(a - b) = \text{Sin}^2 a - \text{Sin}^2 b$

7. Solve $\dfrac{x-2}{y-1} = \dfrac{3}{5}$ and $\dfrac{x-1}{y} = \dfrac{2}{3}$

   $\therefore \dfrac{x-1}{y} = \dfrac{x}{y} - 1 = \dfrac{2}{3}$

   $\therefore \dfrac{x}{y} = \dfrac{2}{3} + 1 = \dfrac{5}{6}$

   $\therefore x = 5, \text{ and } y = 6.$

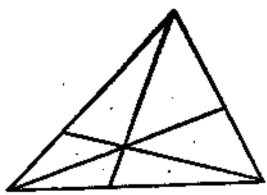
8. How many triangles are there in this figure?

   There are 12 lines.

   Each triangle has 3 sides.

   $\therefore \dfrac{12}{3} = 4\,.$

   $\therefore 4 \times 4 = 16$ triangles.



 Answers on pages 145–146

QUIZ NO. 37 *CAN YOU ARRANGE THESE?*

1. A head boy and a head girl are to be chosen from the senior form of a school. In how many ways is this possible if the form has 12 boys and 10 girls?

2. 6 boys are to be photographed in a row. How many different arrangements can be made of the order in which they are to sit?

3. The same 6 boys are to sit around a table for lunch. How many different arrangements can be made of the order in which they are to sit?

4. The first three letters of a telephone number indicate the name of the exchange. How many such arrangements of 3 letters is it possible to devise from the 26 letters of the alphabet?

5. How many different forecasts must be made of 4 football games in order to ensure that one forecast is correct?

6. In how many different ways can two dice, one red and one blue, be thrown?

7. One of the crews in the University boat race has a problem for its captain. 3 of the crew are stroke-side oarsmen only and 2 of them are bow-side oarsmen only. Ignoring weights and personal preferences, in how many ways can the captain arrange his 8 men to form the crew? The cox is selected and does not change.

 Answers on pages 147–149

QUIZ NO. 38 *PUZZLE THESE OUT*

1. A water-lily doubles itself in size each day. From the time its first leaf appeared to the time when the surface of the pond was completely covered took 40 days. How long did it take for the pond to be half-covered?

2. A pint bottle had all its dimensions doubled. What is the volume of the new bottle?

3. From London to Oxford is 60 miles. Two trains leave at 10.00 a.m., one train from London at 40 m.p.h. and the other from Oxford at 50 m.p.h. When they meet, are they nearer to London or to Oxford?

4. Spot the wrong number in these series of numbers:
   (a) 1, 2, 4, 8, 15, . . .
   (b) 1, 7, 27, 64, 125, . . .
   (c) 10, 15, 21, 25, 30, . . .

5. What is the missing number in these series:
   (a) 81, 27, ..., 3, 1, . . .
   (b) 1, 4, 9, ..., 25, . . .
   (c) 2, 6, 12, ..., 30, . . .

6. If a half-crown is placed on the table, how many half-crowns can be placed round it touching it and each other?

7. Write down the Roman numerals from One to Six as seen on a clock-face.

 Answers on page 150

QUIZ NO. 39 HOLIDAYS ABROAD—BUT WHERE?

'The picture of contentment' shows a family gathered round a warm log-fire on a cold winter's evening. What are 'they' doing? Planning next year's summer holiday! Letters are written. In some of the replies the following were included, and you have to name the country they wrote to.

1. We can give you full board at 85 Pesetas per day.
2. The cheapest suitable fare we can offer is at 40 Bahts a day.
3. You will be comfortable and well-fed at 74 Schillings a day.
4. Our rate is 84 Drachmae per day.
5. 1000 Yen per day is our cheapest rate.
6. About 60 Escudos is the normal cost.
7. The inclusive cost is 1750 Lire a day.
8. 54 Soles per day is cheap for good fare.
9. You will find the usual cost in a good hotel to be 15 Kyats a day.
10. 20 Levas a day is the price we quote.

 Answers on page 151

QUIZ NO. 40 *THE CUP WINNERS?*

The answer to each question below will give you a letter. If these are written down they will form an anagram of the name of a well-known football club.

1. A strange letter to represent 'pence'.
2. $1.2.3.4 \ldots (n-2).(n-1).(n) = ?\,!$
3. Represents the first term in the formulae of an A.P. and a G.P.
4. For a circle, $c = \pi$ times ?
5. The obvious letter for number of terms.
6. Stands for 'initial' velocity.
7. Equals 2·71828 – – – – – –.
8. If the series is 9, 27, 81 etc., 'it' = 3.
9. The abbreviation for 1000 cc.
10. Normally used to represent 'distance'.

 Answers on page 152

QUIZ NO. 41 *QUEER FIGURES FORMED BY FIGURES*

									1										
								1		1									
							1		2		1								
						1		3		3		1							
					1		4		6		4		1						
				1		5		10		10		5		1					
			1		—		—		—		—		—		1				
		1		7		21		35		35		21		7		1			
	1		8		28		56		70		56		28		8		1		
1		—		—		—		—		—		—		—		—		1	

4	9	2
3	5	7
8	1	6

1. Write down the seventh line of figures in the arithmetical triangle.

2. What are the missing numbers in the last line of the arithmetical triangle?

3. Where in the arithmetical triangle do the coefficients of the terms of $(x + a)^2$ and $(x + a)^3$ appear?

4. Use the triangle to work out the coefficients of $(x + 2)^4$.

5. Who is the mathematician associated with this triangle?

6. Find the sum of the numbers in each column, each row, and each diagonal of the square printed above. What name is given to a square built in this way?

7. Complete a 'number' square built in the same way as the one printed above, given:

16	2	12
6	—	—
8	—	—

8. Construct a 'number' square of four rows and four columns such that the sum of each column, row, and diagonal is the same, and given that the top row is 1, 15, 14, and 4, and the left-hand column is 1, 12, 8, and 13.

 Answers on pages 153–155

QUIZ NO. 42 *FUN WITH PROBLEMS*

1. The first five terms of the series 10, 20, 30, 40, 50 add up to 150. What five terms of another series, without fractions, add up to 153?

2. Find three vulgar fractions of the same value using all the digits 1 to 9 once only. Here is one solution of the problem:

$$\tfrac{3}{6} = \tfrac{7}{14} = \tfrac{29}{58}.$$

3. A barrow boy has only three weights, but with them he can weigh any whole number of pounds from 1 lb. to 13 lb. inclusive. What weights has he?

4. Can you by adopting a mathematical process, such as $+$, $-$, $\times$, $\div$, $\sqrt{}$, etc., use all and only the digits 9, 9, 9 to make (a) 1, (b) 4, (c) 6?

5. From where on the surface of the Earth can you travel 100 miles due South, then 100 miles due West and finally 100 miles due North to arrive again at your starting point?

6. A train travelling at 60 m.p.h. takes 3 seconds to enter a tunnel and a further 30 seconds to pass completely through it. What is the length of the (a) train, (b) tunnel?

 Answers on page 156

QUIZ NO. 43 *WHAT CAN THEY REFER TO?*

In this Quiz you can test your general knowledge with special reference to mathematics. This is not intended to test the 'wrangler', and some of us may be pleased that no calculations are involved. All the answers are very brief, so it is useless to attempt to cover up ignorance with a host of words! It is tantalizing to have the answer on the tip of your tongue and yet to be unable to give it. So go to it and see if your general knowledge is up to the mark. What do the following refer to?

1. 'noe two thynges can be moare equalle'.

2. Ludolph's number.

3. Cossic art.

4. The sieve of Eratosthenes.

5. The golden section.

6. The ambiguous case.

7. A gnomon or style.

8. Casting out the nines.

9. The curve of quickest descent.

10. A soraban.

 Answers on pages 157–159

QUIZ NO. 44 SCRUM DOWN AGAINST SOME SERIES

Here you are faced with a succession of terms or quantities, which, after the first term or quantity, are formed according to a common law. This sounds very complicated, but 1 grain of common sense plus 2 grains of confidence is all that is necessary to have some fun with the following series.

1. My reciprocals are in A.P. and I hope I am of some interest in the theory of sound. What is my name?

2. The ratios of successive terms of this series are connected with plant growth. The leaves of a head of lettuce and the layers of an onion grow like this. What is my name?

3. What is the sum of the first 20 terms of this series?
$1 + 3x + 5x^2 + 7x^3 + \dots$

4. What is the 8th term and also the sum of the first 8 terms of this series?
$5.7.9 + 7.9.11 + 9.11.13 + 11.13.15 + \dots$

5. Is the logarithmic series,
$$\log_e (1 + x) = x - \frac{x^2}{2} + \frac{x^3}{3} - \frac{x^4}{4} + \dots$$
useful for working out logarithms to the base 'e'?

6. What is the name of this series?
$$x - \frac{x^3}{3!} + \frac{x^5}{5!} - \frac{x^7}{7!} + \dots$$

7. What is the name of this series?
$$1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \dots + \dots$$

 Answers on pages 160–162

QUIZ NO. 45 GIVE THE CREDIT WHERE IT IS DUE

In this Quiz the term 'Father' is used and its meaning includes not only the mathematician who conceived the first ideas on a particular subject, or invented a piece of apparatus, but also the author of a mathematical book or treatise. Thus Newton is called the Father of the Principia. Who is the Father of . . . ?

1. Geometry?

2. the great work of 13 'books' called the *Elements*?

3. the requirement that geometrical constructions be confined to a ruler and a pair of compasses?

4. our notation of the Calculus?

5. modern number theory and the electro-magnetic telegraph?

6. *The Grounde of Artes*?

7. some special 'numbers' published in his *Ars Conjectandi* in 1713?

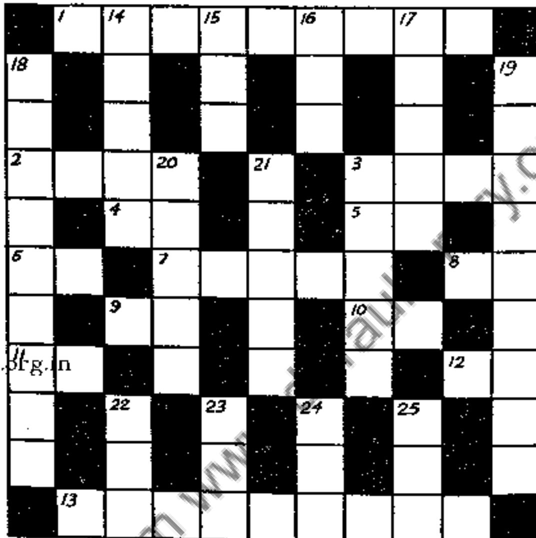
8. the complete solution of the problem of a vibrating string in Sound, and the *Mécanique analytique*?

9. the world map made by projecting a spherical surface on a plane?

10. the papyrus with the title 'Directions for knowing all dark things'?

 Answers on pages 163–165

QUIZ NO. 46 *CROSS SWORDS WITH ME*



ACROSS

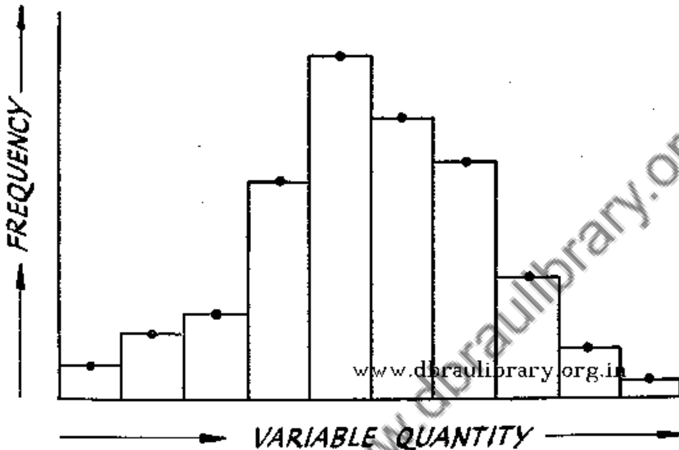
1. 'Tots'.
2. Set for the unwary in examinations.
3. 'The Pointers' always point to one of these.
4. Reversed abbreviation for a particular chord of a parabola.
5. The beginning and end of 17 down.
6. Roman figures for 55.
7. Did it really impress Newton?
8. This looks perfect on your bank statement.
9. He went on to complete the carving of his initials.
10. The area of a rectangle.
11. 2·54 of these equal 1 in.
12. The unit, 33,000 foot-pounds per minute.
13. The obvious use for a scale.

DOWN

3. The mathematician who discovered the laws of refraction of light.
14. The monetary unit of Yugoslavia.
15. A frequent incorrect abbreviation for inches.
16. Given when money is borrowed.
17. Indicates orientation on a plan.
18. He wrote the oldest extant Greek mathematical treatises.
19. Graphs that resemble histograms.
20. A useful table for surveying.
21. Used by the Egyptians to mark out their fields.
22. A positive number.
23. The metric system of units.
24. Indicates a negative characteristic in logarithms.
25. A trigonometrical ratio which is written as if it were evil.

 Answers on pages 166–167

QUIZ NO. 47 SOME STATISTICAL STUDIES



What is the name of . . .

1. this special column-graph?
2. the shape formed by joining the mid-points of the tops of the columns?
3. the curve of frequencies shaped like a 'cocked hat'?
4. the arithmetical average of the values of a variable quantity?
5. the most frequently observed value of a variable quantity?
6. that which indicates the spread of the observed values of a variable quantity?
7. the graph drawn to represent the variations of a certain function with time?

 Answers on pages 168–169

QUIZ NO. 48 DÉROUILLEZ VOTRE FRANÇAIS

1. Citez les mathématiciens grecs qui ont fait de la géométrie, jusqu'alors abstraite, une science moderne.

2. Quel mathématicien affirma que la race humaine était condamnée, puisque la population croit en proportion géométrique, alors que les ressources alimentaires croissent seulement en proportion arithmétique?

3. Quel est le nombre auquel les Babyloniens et les Hébreux attribuaient la valeur 3, et les Egyptiens soit la valeur $\sqrt{10}$, soit la valeur $\left(\frac{4}{3}\right)^4$?

4. Les Grecs étaient de brillants mathématiciens, mais il y avait un domaine dans lequel ils n'osaient s'aventurer. Lequel?

5. Quel fut le premier géomètre grec connu?

6. Pouvez-vous démontrer, en vous appuyant sur les autres axiomes fondamentaux, que par un point on ne peut mener qu'une parallèle à une droite?

7. Dans la recherche des dérivées, quand égale-t-on Δx à 0?

8. En regardant au travers du viseur d'un appareil de photographie, on voit exactement l'ensemble de ce que l'on veut photographier. Vrai ou faux?

 Answers on pages 170–171

QUIZ NO. 49 *CIRCLES, CIRCLES, AND MORE CIRCLES*

Given the following clues, can you name the circle which is implied?

1. It seems to be 'a manager', but the two tangents from any point on it to an ellipse are at right angles.

2. It seems as if this circle could be helpful to an ellipse.

3. Is a circle very much tied up with the feet of the altitudes and the mid-points of the sides of a triangle. What size shoe did Clementine wear?

4. Two circles which cut 'right' across each other.

5. The circle which touches all the sides of a polygon.

6. King Alfred did not really name this circle!

7. The circle which seems to be suffering from 'Spring-Fever'.

8. A triangle is greedy enough to have more than one of these circles.

9. A circle which passes through the vertices of a triangle.

 Answers on pages 172–173

ANSWERS TO QUIZ NO. 1

1. yards in one mile.
2. pounds in one ton.
3. square yards in one acre.
4. acres in one square mile.
5. the square root of three.
6. yards in one rod, pole, or perch!
7. yards in one chain.
8. days in a leap year.
9. the logarithm of two to the base ten.
10. pennies in one pound sterling.
11. the logarithm of three to the base ten.
12. the logarithm of π to the base ten.
13. pounds in one stone.
14. the square root of two.
15. cubic inches in one cubic foot.
16. shillings in a guinea.
17. square yards in one square pole.
18. pounds is the weight of one cubic foot of water.
19. degrees in one right angle.
20. feet per second is the same as 60 miles per hour.

ANSWERS TO QUIZ NO. 2

1.

$$\begin{array}{r} 2228 \\ 1261 \\ \hline 3489 \\ \hline \end{array} \qquad \begin{array}{r} 113 \\ 624 \\ 147 \\ 526 \\ \hline 1410 \\ \hline \end{array}$$

2.

$$\begin{array}{r} 4472 \\ 4351 \\ \hline 121 \\ \hline \end{array} \qquad \begin{array}{r} 6235 \\ 5828 \\ \hline 407 \\ \hline \end{array}$$

3.

$$\begin{array}{r} 47 \\ 53 \\ \hline 235 \\ 141 \\ \hline 2491 \\ \hline \end{array} \qquad \begin{array}{r} 5467 \\ 898 \\ \hline 43736 \\ 49203 \\ 43736 \\ \hline 4909366 \\ \hline \end{array}$$

4. $5x - 5 = 4x - 3$ $\quad x = 2$ $\qquad x^2 - 4x = 21$ $\quad x = 7$ or -3

ANSWERS TO QUIZ NO. 3

1. $=$

Both the Greeks and the Arabs used a letter for 'equals'. In the Middle Ages the full word was employed, and in the 17th century Descartes used the variation symbol to denote equality. Robert Recorde in his algebra book introduced the two familiar short lines in 1557.

2. $\times$

The multiplication symbol was probably first introduced by William Oughtred. It had previously been used for other purposes in mathematics, but one can see why it was not adopted in algebra because of its resemblance to the letter 'x'. By the later half of the 19th century it was used in elementary arithmetic.

3. $\surd$

Ancient writers usually wrote the word 'root', and this practice was followed by the use of the letter 'r'. The first known use of the present symbol was made by a German named Rudolff in 1526, and it is said that he invented it because the symbol resembles the letter 'r'. It was not universally adopted until the 17th century.

4. $\propto$

This sign has been used for the symbol of equality, as also has the mirror-image of it. In science the words 'varies as' are often used and the mathematical symbol '$\propto$' means precisely this. If $a \propto b$, then it follows that $a = \mathbf{k} . b$, where $\mathbf{k}$ is a constant.

5. $>$

Oughtred had suggested symbols for 'greater than' and 'less than', and hence when the present symbols were proposed by his contemporary Thomas Harriot, an English mathematician, they were not readily accepted. After they were used in print in 1631 they slowly gained favour. However, Oughtred's symbols were still in use in the 18th century.

6. ∞

This symbol was used for ten thousand by the Greeks. The symbol representing a large number was called infinity. In 1665 John Wallis took the symbol for ten thousand to be the symbol for a large number.

7. : :

William Oughtred is also responsible for this proportion symbol, which appears in his *Clavis Mathematicae*, an algebra book published in 1631. Curiously enough, Oughtred used a dot to denote a ratio, the symbol now used for a multiplication sign.

8. $_nC_r$

The interest in selections goes back to the time of the early Chinese and Hindu mathematicians, but it was not until the late 17th century that the word 'combination' was used in its present sense. Strictly speaking, $_nC_r$ is an abbreviation and not a symbol.

9. π

Although this symbol was first used in 1706 to represent the ratio $\frac{\text{Circumference}}{\text{Diameter}}$ for any circle, it was not widely adopted until late in the 18th century. The Swiss mathematician Euler was attracted by it and did much to increase its popularity. Previously π was used to denote the periphery of a circle.

10. a^3

It was René Descartes who in 1637 wrote aa or a^2 to mean multiplying a by itself and a^3 to mean the product of a^2 and another a. John Wallis and Isaac Newton explained the ideas of negative and fractional indices, and thus extended the invention of Descartes.

ANSWERS TO QUIZ NO. 4

1. 5 *GIRLS*

5 girls pack 5 boxes in 5 minutes,
5 girls pack 1 box in 1 minute (working on the same box!),
5 girls pack 50 boxes in 50 minutes.

2. 47 *SECONDS*

The time taken will be 47 seconds because the 47th cut produces the last two squares.

3. 44 *INCHES*

Steel bars are often used as rollers in this way. The safe moves forward twice the length of the circumference of one of the steel bars. This distance is therefore $\frac{2.22.7}{7}$ inches,

which is 44 inches. With three or any number of rollers under the safe it will still move forward 44 inches. The best way to see this is to consider this problem in two parts:

(a) the motion forward caused by one revolution of the rollers if they were rolling off the ground,

(*b*) the motion forward of the centres of the rollers because they themselves roll forward on the ground.

In both cases the motion amounts to 22 inches, so that the total movement of the safe mounted on the rolling rollers is 44 inches.

4. 20,000

Did you get this right? It really does not matter what percentage of the population is one-legged! All the one-legged people will only require one shoe in any case. Of the remainder, half will wear no shoes and the other half will carry two shoes on their two feet. This works out at one shoe per person for the 'others'. We shall therefore need for the whole population on the average one shoe per person.

5. $99\frac{99}{99}$

This is one of the old trick-problems. If recognized signs were introduced you could arrange six 'nines' to give 100 as follows:

$$[(9 \times 9) + 9] + 9\frac{9}{9}$$

You could also arrange four 'nines' to give 100 as follows:

$$99\frac{9}{9}$$

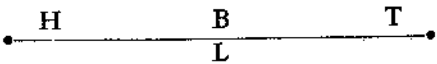
6. *ALL THE NUMBERS* 0 *TO* 9 *APPEAR*

This is interesting, but it is by no means the only example of composing 100 from all the numbers 0 to 9 taken once only. Examine these solutions:

(a) $0 + 1 + 2 + 3 + 4 + 5 + 6 + 7 + 8.9$
(b) $78\frac{3}{6} + 21\frac{45}{90}$
(c) $89 + 6\frac{1}{2} + 4\frac{35}{70}$
(d) $90 + 8\frac{3}{6} + 1\frac{27}{54}$

Can you design more examples still?

7. 128 *INCHES*



Let H represent the head, B the body, T the tail, and L the total length of the fish.
Looking at the problem we are given the following three facts:

$$T = H + \tfrac{1}{4}B$$
$$B = \tfrac{3}{4}L$$
$$H = 4 \text{ in.}$$

It is also true that $L = H + B + T$

In this equation keep L and substitute for everything else.

$$\therefore L = 4 \text{ in.} + \tfrac{3}{4}L + (H + \tfrac{1}{4}B)$$
$$\therefore L = 4 \text{ in.} + \tfrac{3}{4}L + 4 \text{ in.} + \tfrac{3}{16}L$$
$$\therefore L = 8 \text{ in.} + \tfrac{15}{16}L$$
$$\therefore \tfrac{1}{16}L = 8 \text{ in.}$$
$$\therefore L = 8 \times 16 \text{ in.}$$
$$\therefore L = 128 \text{ in.}$$

Thus we see that the fish was 128 inches long.

ANSWERS TO QUIZ NO. 5

1. *THE ABACUS*
The merchants and traders of ancient days in Egypt and Mesopotamia used to set out pebbles in grooves of sand to calculate and add up accounts. There would be a 'units' groove, a groove for 'tens', and one for 'hundreds'. Such was a simple abacus, and the word is derived from a Greek word meaning 'tablet'. In Roman times a calculating frame was made in which pebbles slid on wires and this was also called an abacus. The size of the abacus determined the size of the numbers which could be dealt with. The Roman numerals made simple addition, subtraction, and multiplication very complicated. Calculations were done by slaves using an abacus. It is interesting to note that the Roman word for 'pebble' was 'calculus' and here we have the derivation of our word 'calculate'.

2. 1666
Letters were used by the Romans to represent various numbers, and they seem to follow the pattern set by the Greeks.

1, 5, 10, 50, 100, 500, 1000.
I, V, X, L, C, D, M.

The Roman numerals on the London monument therefore read as:

$M = 1000$, $D = 500$, $C = 100$, $L = 50$, $X = 10$, $V = 5$, $I = 1$.

These added together make 1666, the date of the Fire of London.

3. *MDCCLXXXIX*
$M = 1000$, $D = 500$, $C = 100$, $C = 100$, $L = 50$, $X = 10$, $X = 10$, $X = 10$, and $IX = 9$. Add these all together and the result is 1789.

4. *CLXVI*
This number is 166.

5. *CXLIV*

This number is 144. XL is 10 before 50 which is 40. Similarly IV is 1 before 5 which is 4.

6. *CD*

C	X	VI
	X	III
		VI
CC	LX	V
CD		

The answer of the addition is four C's which is 400. It was the custom not to write four similar numerals consecutively. Hence instead of writing four hundreds (CCCC) the Romans wrote one hundred less than five hundred (CD). Placing the C before the D meant C less than D and placing it after the D, as in DC, meant C more than D. So that CD is 400 and DC is 600.

7. 4 *and* 9

The Roman numeral for four is IV. Therefore, when the left-hand integer is removed there remains the integer V. V is the Roman numeral for five. Hence the four changes to five. Similarly the Roman numeral for 9 is IX, and when the left-hand integer I is removed there remains the Roman numeral X, which is ten.

8. *SURVEYOR*

The 'groma' was an important surveying instrument used by the Roman surveyors or agrimensores. As far as mathematics was concerned the Romans were practical and no more. To them mathematics was a tool that helped them to construct and to measure. The agrimensor was a land- or field-measurer, and in this work he made use of the groma. It was frequently carved on the tombstones of Roman surveyors.

ANSWERS TO QUIZ NO. 6

1. 18 *DAYS*

There are three possible types of day:

(a) Rain in the morning and fine in the afternoon.
(b) Fine in the morning and rain in the afternoon.
(c) Fine in the morning and fine in the afternoon.

Let the number of such days in each category be a, b, and c.
$\therefore$ number of days on which rain falls $= a + b = 13$.
$\therefore$ number of days having fine mornings $= b + c = 11$.
$\therefore$ number of days having fine afternoons $= a + c = 12$.
From these equations we derive that $a = 7$, $b = 6$, and $c = 5$.
$\therefore$ number of days' holiday is $7 + 6 + 5 = 18$.

2. $5\frac{5}{11}$ *MINUTES PAST* 7

At 7 o'clock the M.H. is 35 divisions behind the H.H.
To be opposite one another the M.H. must gain 5 divisions on the H.H.
But the M.H. gains 55 divisions in 60 true minutes.
$\therefore$ the M.H. gains 5 divisions in $5\frac{5}{11}$ true minutes.
All problems concerning the positions of the hands on clock-faces will be solved readily if you draw a sketch and remember that the accurate position is 'something' and 'something' elevenths.

3. 113

1442897 is a 7 figure number and thus the cube root must lie between 110 and 120. As the last figure is a 7 the cube root must end in 3.

4. *SIXPENCE*

Let your algebra help you!

$$C + B = 24$$
$$C = 12 + B$$
$$\therefore B = 6$$

5. 9, 40, *and* 41 *FEET*

The procedure is as follows: square the length of the perpendicular, subtract 1, divide by 2. The result is the length of the base. Add 1 and then that is the length of the hypotenuse. This applies when the perpendicular is any odd number and these combinations of numbers are sometimes called Pythagorean series. Other combinations are 3—4—5, 5—12—13, 7—24—25, 11—60—61, 13—84—85, and so on indefinitely. The method is derived from the theorem of Pythagoras concerning a right-angled triangle.

$$\begin{aligned} H^2 &= B^2 + P^2 \\ \therefore (B+1)^2 &= B^2 + P^2 \\ \therefore 2B + 1 &= P^2 \\ \therefore B &= \frac{P^2 - 1}{2} \end{aligned}$$

6. 15 *FEET*

Let the tree grow x feet each year.
At the end of the sixth year the height of the tree

$$\begin{aligned} &= (3 + 6x) \text{ ft.} \\ \text{The growth } x &= \tfrac{1}{9}(3 + 6x) \\ \therefore x &= \tfrac{1}{3} + \tfrac{2}{3}x \\ \therefore x &= 1 \end{aligned}$$

At the end of the twelfth year the height of

$$\begin{aligned} \text{the tree } &= (3 + 12x) \text{ ft.} \\ &= 15 \text{ feet.} \end{aligned}$$

7. *YES*

Do you know the tests of divisibility? Numbers will divide exactly

by 2 if they end with an even digit,

,, 3 if the sum of the digits is divisible by 3,

,, 4 if the last two digits are divisible by 4,

,, 5 if the last digit is 0 or 5,

,, 6 if divisible by both 2 and 3,

,, 8 if the last three digits are divisible by 8.

What about the tests of divisibility for 7, 9, 11, and 12?

8. *GRADE A: GRADE B = 3 : 1*

Let A parts of grade A be mixed with B parts of grade B cement, then the equation is:

$$12A + 8B = 11(A + B)$$

$$\therefore A = 3B$$

$$\therefore \frac{A}{B} = \frac{3}{1}$$

ANSWERS TO QUIZ NO. 7

ACROSS

1. 1728

3. 33

5. 26. Arith. Mean $= \frac{50 + 2}{2}$

6. 981

7. 5280

10. 1890. S. Int. $= \frac{P \times r \times T}{100}$

$$= \frac{18900 \times 5 \times 4}{100 \times 2}$$

12. 144

1 girl must sit down in any place and then the other boys and girls can be arranged round her at the table.
The seat next but one to her on her left can be occupied by any 1 of 3 girls . . . that means in 3 ways.
The seat opposite to her can then be occupied by either 1 of the 2 remaining girls . . . that means in 2 ways.
The seat next but one to her on her right can only be occupied by the last remaining girl . . . that is in 1 way.
∴ the girls can be seated in $3 \times 2 \times 1$ or $3!$ or 6 ways.
Similarly the boys can be seated in $4 \times 3 \times 2 \times 1$ or $4!$ or 24 ways.
∴ the girls and boys can be seated in 6×24 or 144 ways.

14. 45. The regular octagon has 8 equal sides.

∴ the angle at the centre is $\frac{360}{8} = 45°$.

16. 25. Diagonal^2 = Sum of squares on the other two sides.
$= (3 \times 5)^2 + (4 \times 5)^2$
$= (5 \times 5)^2$

17. 1458. This series has a common ratio of 3.
∴ the 6th term is $6 \times 3^5 = 6 \times 243$

DOWN

1. 12

2. 765. (Note: 88 ft. per sec. = 60 m.p.h.)

3. 38. (Note: Opposite angles of a cyclic quadrilateral = 180°)

4. 3142

6. 9009. A number is divisible by 11 if the sum of the digits in the even places equals the sum of the digits in the odd places.

8. 2814. A quick rule to find this answer is to add π times the width to the internal circumference and then multiply by the width. Why is this so?
Area = $(3\frac{1}{7} \times 10 + 250)\ 10$

9. 1812. To find whether a year is a leap-year divide the number formed by the last two digits by 4, except when they are both zeros. If they are both zeros divide the first two digits by 4. In each case if there is no remainder then the year is a leap-year. 1804, 1808, and 1812 are leap-years, but 1800 is not.

11. 045. Directions in air-navigation are given as angles of three figures in a clockwise direction from North.

13. 45°

15. 58. The sides of this triangle are in the ratio of 1, $\sqrt{3}$, and 2.

ANSWERS TO QUIZ NO. 8

1. *EQUILATERAL*
As the name suggests, all the sides are equal. A noticeable feature about the warning traffic signs is that they are surmounted by red equilateral triangles. Equilateral triangles have not only equal sides but have equal angles too and can thus be called equiangular triangles.

2. *ISOSCELES*
The word means 'equal legs'. Any triangle which has two of its three sides equal is called an isosceles triangle. If we look around us we can often find geometrical figures in nature. In the construction of houses, ships, and aircraft the isosceles triangle is often encountered.

3. *SCALENE*
This is a triangle which is 'uneven' because it has all its sides unequal. The word 'scalene' has nothing to do with drawing to scale, but is derived from the Greek word '*skalenos*' which means 'uneven' or 'unequal'.

4. *PEDAL*
This triangle is sometimes called the orthocentric triangle. If AD, BE, and CF are the perpendiculars dropped from the vertices of the triangle ABC to the opposite sides, then the triangle DEF is the pedal triangle. The three perpendiculars pass through a common point called the orthocentre.

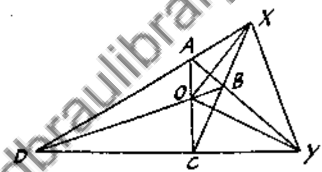
5. *RIGHT-ANGLED*
The unique property of the right-angled triangle ABC is that if angle A is the right angle then $a^2 = b^2 + c^2$. The geometrical proof of this property is associated with the Greek mathematician Pythagoras who lived in the 6th century B.C. Triangles whose sides are in the ratios 3—4—5 or 5—12—13 are right-angled.

6. *SIMILAR*

Two triangles are said to be similar if they have their angles equal to one another and have their sides, taken in order, about the corresponding equal angles proportional. The areas of similar triangles are proportional to the squares of their corresponding sides.

7. *HARMONIC*

ABCD is the quadrilateral and OXY is the harmonic triangle. It is formed by joining the intersection points of the sides and the intersection point of the diagonals.



8. *SPHERICAL*

A spherical triangle consists of a portion of a sphere bounded by three arcs of great circles. Obviously the sides do not consist of straight lines. The sum of the three angles of such a triangle lies between 180° and 540°. Much of the early work with spherical triangles was done by Menelaus about A.D. 100.

9. *ISOSCELES*

The particular proposition proved that the angles at the base of an isosceles triangle are equal. The title 'Pons Asinorum' means the 'Bridge of Asses'. It is said that in the Middle Ages the 'donkey' could not pass over this bridge to continue his study of Euclidean geometry but the name may be due to the fact that the figure in Euclid resembles a simple truss bridge.

10. *EQUILATERAL*

One has only to look at a laburnum or a clover leaf to see the perfect symmetry suggesting the equilateral triangle. It is always good fun to look for geometrical shapes in roots, stems, leaves, and flowers of plants.

ANSWERS TO QUIZ NO. 9

1. *Café—40 Francs. Gâteau—30 Francs.*
Si vous trouvez juste, vous avez résolu un système classique de deux équations à deux inconnues: par soustraction vous trouvez le prix d'un gâteau, puis en remplaçant, celui d'un café.

2. *IMPOSSIBLE*
S'il est nécessaire de partager un angle en trois parties égales, on peut le faire avec autant de précision qu'on le veut, mais avec règle et compas seulement, ce n'est pas possible.

3. *SUPERPOSITION*
C'est la démonstration par superposition, généralement utilisée lorsqu'on veut prouver une égalité par la coincidence.

4. *OUI*
On construit un triangle rectangle dont les côtés de l'angle droit ont une longueur unité. L'hypoténuse a pour longueur $\sqrt{2}$. Il suffit de construire ensuite le triangle rectangle de côtés $\sqrt{2}$ et 1; l'hypoténuse vaudra $\sqrt{3}$ et on continue de proche en proche.

5. 1
Puisque l'hypoténuse, qui est toujours le plus grand côté d'un triangle rectangle, figure au dénominateur, les deux rapports sont toujours inférieurs à 1.

6. (1) UN POINT n'a ni longueur, ni largeur, ni épaisseur.
(2) UNE LIGNE n'a seulement qu'une longueur.
(3) UNE SURFACE a longueur et largeur.
(4) UN VOLUME a longueur, largeur, et hauteur.

7. *PAR L'ABSURDE*

C'est un raisonnement 'par l'absurde', méthode indirecte souvent utilisée en géométrie. Elle consiste à montrer que la proposition est vraie parce que si elle ne l'était pas, on serait amené à une conclusion absurde. Voir plusieurs postulats d'Euclide.

8. *LA ROTATION*

C'est le raisonnement utilisant la rotation. Dans ce genre de raisonnement on suppose qu'une ligne, qu'un plan etc. tourne autour d'un axe. Ce qu'on utilise d'ordinaire est l'angle de rotation.

ANSWERS TO QUIZ NO. 10

1. *ARCHIMEDES*

He was one of the earliest mathematicians and lived in the 3rd century B.C. He attended lectures at Alexandria University and returned to Sicily, his birthplace, where he spent the rest of his life. He possessed great ability and is well known because of his inventions. One of his famous achievements is the Archimedean screw. Some of his writings still exist and these include works on the circle, the spiral, the sphere, the cylinder, and arithmetic.

2. *DESCARTES*

He was a contemporary of Galileo and was born near Tours in France in 1596. As a mathematician he is best known for his contributions to analytical geometry. Everyone who has drawn a graph has used Cartesian co-ordinates, named after Descartes. He was the first person to announce this useful discovery. Descartes published works on algebra and astronomy as well as the first treatise on co-ordinate geometry which was called *La Géométrie*.

3. *MENELAUS*

Menelaus of Alexandria lived in the 1st century A.D. He is well known for his extant work on spherical trigonometry. His writings on plane trigonometry are unfortunately lost. In more advanced geometry we generally learn after Ceva's theorem another theorem attributed to Menelaus. This deals with a transversal meeting the sides of a triangle internally or externally.

In the author's *Science for Fun* mention is made of Halley's comet; it is interesting to note that it is the same Halley who edited the works of Menelaus.

4. *CARDANO*

This Italian name is often spelt as Cardan in English. He lived in the 16th century and won fame for his published works on arithmetic and algebra. Another mathematician, Tantaglia, had discovered a solution of cubic equations which he passed on in confidence to Cardano. The latter, however, published it in his treatise on algebra.

5. *NAPIER*

John Napier was a Scottish mathematician who lived in the latter half of the 16th century and the early years of the 17th century. His discovery of logarithms would alone give him fame. He invented a means of making calculations by means of 'bones' or 'rods'. To Napier is also frequently attributed the honour of writing decimal fractions with a full-stop. This practice is something we readily accept without giving a thought to the discoverer.

6. *WALLIS*

John Wallis was another 17th-century mathematician who became Savilian professor of geometry at Oxford. He was a profuse writer and his treatise on algebra is most comprehensive. Wallis was one of the founders of the Royal Society in 1645.

7. *OUGHTRED*

A 17th-century English mathematician who published a good text-book on arithmetic in which he introduced new symbols. To Oughtred is accredited the first use of the abbreviations sin, cos, and tan. The invention of the slide rule is also due to him. He was a good teacher and corresponded with most of the leading mathematicians of his time. It is reported that his death was caused by the excitement of hearing of the restoration of Charles II to the throne.

8. *LAPLACE*

He was born in Normandy in 1749, and he is sometimes known as the 'Newton of France' for he was a great theoretical astronomer. He had the gift of being able to apply mathematical methods to astronomy, molecular physics, electricity, and magnetism. His complete works have been published in 14 volumes. He discovered the invariability of the major axes of the planetary orbits, and explained the movements of the planets Jupiter and Saturn. In this and other ways he solved many of the problems of the solar system. He introduced the famous nebula theory in which he maintained that the solar system was the result of a contracting nebula. His work called *Traité de Mécanique Céleste* deals with the motion of the solar system. He discovered a famous differential equation which has since been named after him.

9. *EULER*

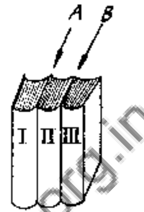
He was an 18th-century Swiss mathematician who was closely connected with the Bernoullis. Euler was a prolific writer on all sorts of mathematical subjects, and even after he became blind he continued to work. He was responsible for the symbol 'e' which is the base of natural logarithms. Euler used this symbol in 1731. He made the present trigonometrical abbreviations and the use of π more general.

10. *DEMOIVRE*

His name is more correctly written de Moivre. He was an 18th-century French mathematician who lived most of his life in London. The *Principia* made him interested in mathematics and amongst his contributions we have Demoivre's theorem in trigonometry. He was appointed by the Royal Society to the commission concerning the controversy as to whether Newton or Leibnitz discovered the calculus.

ANSWERS TO QUIZ NO. 11

1. *ONE INCH*



Surely the bookworm has only to go from A to B as in the figure! This distance is the thickness of Volume II—one inch.

2. *THE NORTH POLE*

One cannot imagine that there is a cubical igloo at the North Pole! But if there were and if it had windows they would all have a southern outlook.

3. 630 *LITRES*

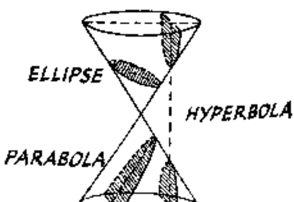
Let x be the volume of the second barrel. Your equation will be:

$$\frac{5}{6} \times 336 = \frac{4}{9} \times x$$

$$\therefore x = \frac{5 \times 336 \times 9}{6 \times 1 \times 4}$$

4. *ELLIPSE, PARABOLA, HYPERBOLA*

These three curves are often referred to as 'conic sections'. The sections are shown in the figure—the hyperbola is parallel to the axis, the parabola is parallel to the slant height, and the ellipse is oblique. The base is, of course, a circle.



5. *NINE*

A wins 3 games and thus gains threepence. B has to win back this threepence which takes another 3 games, and finally B wins 3 more games to win the total sum of threepence.

6. 4

If $x =$ the missing digit, then the solution is found from this equation:

$$900 + 50 + x - (100x + 50 + 9) = 100x + 90 + 5$$

Thus the number is 954, and $954 - 459 = 495$.

ANSWERS TO QUIZ NO. 12

1. d *and* πr^2

The circumference of a circle is π multiplied by d, where d is the diameter of the circle. It is better to use πd rather than $2\pi r$ because π is the ratio of the circumference to the diameter of the circle. The area of a circle is πr^2.

2. *ARCUS and CHORDA*

The Latin word for a 'bow' is 'arcus', and for a 'string' is 'chorda'. From these two Latin words we at once recognize the familiar English words 'arc' and 'chord'. These words are first encountered in the geometry of the circle, but the terms are used with reference to all mathematical curves.

3. *FINDING A SQUARE WITH THE SAME AREA AS A GIVEN CIRCLE*

This was one of the problems which confronted the Greek mathematicians. The difficulty lies in the fact that a ruler and compasses only could be used. Attempts to solve the problem go back as far as 460 B.C. . . . if only we could draw a straight line equal to the circumference of a circle!

4. π

This ratio (*see* answer 1 above) is very important and has been investigated since earliest mathematical times, but it was not until 1706 that an English writer, William Jones, definitely used π to mean the same as it does today.

5. 16·13 *INCHES*

In 60 minutes the tip of the minute hand of the clock makes one complete revolution tracing out the circumference of a circle whose radius is 7 in.

in 60 minutes the tip moves through πd in.

$$\text{or } \frac{22}{7} \times 2 \times 7 \text{ in.}$$

in 22 minutes the tip moves through $\frac{22}{7} \times 2 \times 7 \times \frac{22}{60}$ in.

$$\text{or } 16{\cdot}13 \text{ in.}$$

6. *A CYCLOID*

The cycloid is an attractive curve and it was given this name in 1661. Many well-known mathematicians have studied the properties of this curve—especially Galileo, Pascal, Bernouilli, and Huygens. If you wish to construct this curve, make a mark on the rim of a tin lid. Roll the lid on a sheet of paper and up against a straight edge. Trace the path of the mark on the paper with a pencil. The resulting curve which repeats itself continuously is a cycloid.

7. *FOUR TIMES THE DIAMETER OF THE WHEEL*

The mark will trace out a cycloid as the cycle moves forward. At every point where a cycloid touches its base line there is a cusp. The distance from cusp to cusp is πd, but the length of the curve from cusp to cusp is 4d, where d is the diameter of the generating circle. In this particular case d is the diameter of the bicycle tyre.

8. Area of a circle $= \frac{\pi}{4}$ (diameter)^2

$\therefore$ Area of semi-circle BAC $= \frac{\pi}{8}$ BC^2

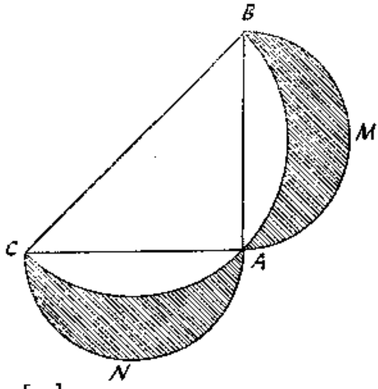
But BC^2 = AB^2 + AC^2

$\therefore$ Area of semi-circle BAC = Area of semi-circle ABM + Area of semi-circle ACN.

Subtracting the segments common to both sides of this equation: Area of $\triangle$ ABC = Area of both lunes.

$\therefore$ Area of each lune = $\frac{1}{2}$ Area of the triangle ABC.

Note that for any right-angled triangle: Area of the triangle = Area of both lunes.



ANSWERS TO QUIZ NO. 13

1. $16\frac{5}{8}$

This problem is to be found in the ancient Rhind papyrus or Ahmes papyrus written more than a thousand years before Christ. The original wording appears strange: 'heap, its seventh, its whole, it makes nineteen'.

The solution is found thus:

$$x + \frac{x}{7} = 19$$

$$\therefore 8x = 133$$

$$\therefore x = 16\tfrac{5}{8}$$

2. 60

This problem is traditionally attributed to Sun Tsu who lived in the 1st century A.D. His method of solving the problem did not involve the usual unknown quantity 'x'. He did not give us the solution but only the answer—perhaps he guessed. The modern solution is:

Let x = the number of guests.

Equating the number of dishes from the information given,

$$\frac{x}{2} + \frac{x}{3} + \frac{x}{4} = 65$$

$$\therefore 6x + 4x + 3x = 65 \times 12$$

$$\therefore 13x = 65 \times 12$$

$$\therefore x = 60$$

3. 60 *YEARS*

This is an example of the type of problem which was popular in the 4th century. It is easily solved by letting his age be represented by x years.

$$\text{Then } \frac{x}{4} + \frac{x}{5} + \frac{x}{3} = x - 13$$

$$\therefore 15x + 12x + 20x = 60x - (60 \times 13)$$

$$\therefore x = 60$$

4. 9

This is an example of an easy quadratic equation. Let us solve it in this way.

Let x be the number of runs scored by Ruck.

Then $x^2 - x - 72 = 0$

$\therefore (x - 9)(x + 8) = 0$

$\therefore x = 9$ or -8

Clearly the answer needed here is 9. Ruck scored 9 runs. But what is the significance of the -8? Is minus 8 a possible solution of the mathematical equation? Yes, it is. If Ruck scored -8, then -8 times $-8 = +64$, then subtracting his score from this gives $64 - (-8) = 72$, and taking off 72 more leaves $72 - 72 = 0$, a 'duck'. Thus -8 is a possible solution but inapplicable.

5. 2 *OUNCES*

The solution of this problem involves the same argument as the last one.

Let the weight of the ball be x ounces.

Then $2x + x^2 - 8 = 0$

$\therefore (x - 2)(x + 4) = 0$

$\therefore x = 2$ or -4

6. 90 *FEET*

Applying the theorem of Pythagoras to both of the right-angled triangles:

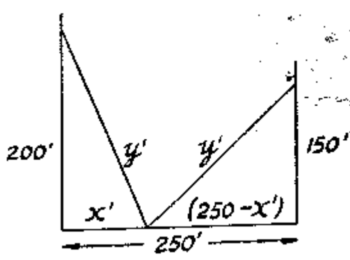
$y^2 = 200^2 + x^2$

$y^2 = 150^2 + (250 - x)^2$

$\therefore 40000 + x^2 = 22500 + 62500 - 500x + x^2$

$\therefore 500x = 45000$

$\therefore x = 90$



ANSWERS TO QUIZ NO. 14

1. *HEXAGON*
The hexagonal shape of the open end of the bee's cell is a familiar sight to some people. In ancient times it was concluded that bees had a certain geometrical aptitude or sense. The hexagon is one of the few regular shapes that can completely fill the space on a bee frame. Foundation for worker brood is generally made to give comb with about 5 cells per inch run, thus producing 26 to 29 worker cells per square inch.

2. *TRIANGLE*
The triangle is the only rigid rectilinear figure, and this can readily be proved by joining three, four, or five meccano rods together in a closed figure and applying pressure! This is the reason for the tie-bar or tie-beam in buildings and gates.

3. *SEMI-CIRCLE*
The study of old churches is a most fascinating pursuit and frequently one can recognize the period when parts of a church were built. Arches span the openings between chancel and nave, and the heads of windows and doorways. The Norman arches of the 12th century were semi-circular and have a series of characteristic rings.

4. *PARALLELOGRAM*
A parallelogram is a rectangle which has been 'pushed over' so that its angles are no longer right angles. Its opposite sides remain parallel and equal. Its diagonals still bisect the parallelogram into two equal triangular areas, but its total area will always be less than the area of the rectangle from which it was formed.

5. *DUODECAGON*
This is also called a dodecagon and is a plane figure with twelve sides and twelve angles. Strictly speaking the threepenny piece is a regular duodecagon because it has twelve equal sides.

6. *SQUARE*

It is unusual to find a square in the plant kingdom. It is nevertheless the characteristic feature of the Labiatae family which includes the mints, thyme, sage, ground-ivy, the woundworts, the hemp-nettles, the dead-nettles, and the bugle. They have square stems and the fruit breaks up into four nutlets.

7. *PENTAGON*

The pentagon is a five-sided plane figure. Five is a common number in flower structure. Many flowers have five sepals and/or five petals (e.g. the buttercup). As soon as one examines the tips of the campanula or Canterbury Bell one immediately recognizes the regular pentagon.

8. *RHOMBUS*

This is a square which has been sat on! The rhombus is a parallelogram with all its sides equal, but its angles are not right angles. A square is really a special case of a rhombus.

9. *SQUARE*

The 'Great Square of Pegasus' is a very obvious shape in the heavens because all four stars at the corners are bright and there are no bright stars within the square. It is clearly seen in England almost due south at midnight during the period of the September equinox.

10. *EQUILATERAL TRIANGLE*

These three stars are different distances away from the earth. They are well-known stars of the winter's sky. Aratus, a Greek astronomer-poet, writes:

'Let Procyon join to Betelgeuse and pass a line afar,
To reach the point where Sirius glows, the most conspicuous star,
Then will the eye delighted view a figure fine and vast,
Its span is equilateral, triangular its cast.'

ANSWERS TO QUIZ NO. 15

1. *LIBRA*

The Roman weights and coins were closely linked. About 268 B.C. the new silver denarius was struck and 72 of these made a libra (or pound). Unfortunately as the Romans conquered new countries they did not standardize the weights throughout the Empire, so that there were at least eight different Roman pounds.

2. *UNCIA*

This is the Latin for 'a twelfth part'. It is used with reference to a pound or a foot. The fractional units of these are the ounce and the inch. There are 12 inches in 1 foot but we wonder why there are not 12 but 16 ounces in 1 pound. It is understandable that we all find British units complicated and confusing.

3. *TOWN IN FRANCE*

The Troy weight is apparently named after a weight used at the popular fairs held at Troyes in France. Troy-weight came into use in England in the 13th century, but never ousted the avoirdupois system introduced by the Normans. The Troy pound was forbidden after 1878 when the Weights and Measures Act was passed.

4. *CARAT*

The Troy ounce was permitted as a legal weight and standard after 1878 only for the sale of precious metals and precious stones. It is obvious that the Troy pound and avoirdupois pound both as legal weights would have caused much confusion. The carat weighed originally $3\frac{1}{3}$ grains but is now $3\frac{1}{5}$ grains, or 150 carats make the Troy ounce of 480 grains.

5. *HAND*

The 'hand' was a linear measure of three inches in the 16th century but is now standardized as four inches. It consists of the width of the palm or hand, and is now used only for the height of horses.

6. *ACRE*

The Latin word is 'ager', meaning a field. Units for land measure varied with time. In medieval England, land was measured in terms of the number of yoke of oxen needed to cultivate the land. Then the acre was the amount that a yoke could plough in a day. This unit is still used.

7. *POLE*

Years ago land was ploughed by oxen. The driver's stick or 'pole' was used to encourage the oxen and also to measure the width of the strip to be ploughed. The pole, rod, or perch is $5\frac{1}{2}$ yards long. A square pole is $\frac{1}{160}$th of an acre and came into use as a land measurement in the 15th century.

8. *SCRUPLE*

The dispenser makes up his prescriptions using the apothecaries' weight, in which a Troy ounce is divided into drachms and scruples. The word 'scruple' is derived from the Latin word 'scrupulus' which is $\frac{1}{24}$th of an ounce. The scruple is 20 grains and the drachm is 60 grains. 8 drachms make 1 ounce Troy.

9. *HENRY I*

The name is derived from the Old English word 'gierd' or 'gyrd' which means a 'twig' or 'stick'. This unit varied in England until 1100 when it was standardized by King Henry I. Throughout the realm it was then taken as the distance from the King's chin or nose to his finger-tip.

10. *HUNDREDWEIGHT*

This is an avoirdupois weight used in measuring heavy things. As its name suggests, it probably originally consisted of 100 pounds, but the custom grew of adding an extra few pounds for perishable goods so that it varied considerably in various localities from 100 to 120 pounds. It is now standardized as 112 pounds in England and 100 pounds in the U.S.A.

ANSWERS TO QUIZ NO. 16

1. *TRUE*
The pentagram of Pythagoras is the five-pointed star formed by drawing all the diagonals of a regular pentagon and deleting the sides. Pentagrams, heptagrams, and nonograms were considered to have magical and mystical properties at a very early date. The pentagram in particular was used as a symbol of health and happiness. The Pythagoreans (disciples of Pythagoras) used the pentagram as their badge of recognition.

2. *FALSE*
Zeno was the originator of the paradox of Achilles and the tortoise. Zeno of Elea lived in the 5th century B.C. and he has been associated with many paradoxes of time, space, and motion. Zeno argued that no matter how fast Achilles ran that he could never catch the tortoise, for the latter would move a short distance on as Achilles covered the distance between him and where the tortoise was!

3. *TRUE*
The sensible means of avoiding any confusion between a.m. and p.m. is to use the twenty-four-hour clock. The railway time-tables on the continent of Europe leave no possible doubt about the time of the day or night when a train is due to leave a station. Midnight is expressed as 0000 hours and every time during the day is expressed in four digits. For instance, 9.30 a.m. = 0930 hours, and 12 noon = 1200 hours, and 1.15 p.m. = 1315 hours.

4. *FALSE*
The curve assumed by a chain, rope, or cable when hanging freely between two supports is very much like a parabola, but is really quite different. The curve is called a catenary,

which is derived from the Latin word 'catena', a chain. Galileo thought this curve was a parabola, and it was not until late in the 17th century that the Bernoullis and Leibnitz discovered the peculiar properties of the catenary.

5. *TRUE*

The pantograph can be used to copy any figure composed of any combination of straight lines and curved lines. It can be adjusted to cause the copy to be of the same size or to be enlarged or reduced. The instrument consists essentially of a freely-jointed parallelogram of hinged rods. The lengths of the sides of the parallelogram are varied to produce the different sizes of the copy. The original and the copy are in two dimensions and lie in the same plane.

6. *FALSE*

A histogram is in no way connected with the unit of weight, the gram. It is true that the metric standards are kept at the International Bureau of Weights and Measures at Sèvres near Paris. The histogram is connected with the method of graphical representation of data and is described elsewhere in this book.

7. *TRUE*

In architecture the cantilever is a projecting bracket which is used to support a balcony. There are very many examples of its use in buildings of several generations. It is also of great use in the building of bridges. Two cantilevers stretch out from piers on opposite sides and these are joined together by a girder to complete the span. The Quebec Bridge over the St. Lawrence River in Canada has the longest cantilever span in the world—1800 feet. The largest cantilever bridge in the United Kingdom is the Forth Bridge completed in 1890. Its two main spans are 1710 feet long.

8. *TRUE*

This is the way in which the term 'parameter' is used in mathematics when dealing with the equations of curves and surfaces. It came into use about 100 years ago. The use of parametric equations frequently simplifies calculations in algebraic geometry and the calculus. Parameter means a 'side measure'. For instance the co-ordinates of a point on a parabola expressed in terms of one parameter 't' can be written as at^2, $2at$.

ANSWERS TO QUIZ NO. 17

1. *MEDIAN*
This is the definition which is usually given of a median. The three medians of a triangle are concurrent, and the point at which they intersect is one third of the way along each median measured towards the vertex from the mid-point of the opposite side.

2. *STRAIGHT LINE*
This was the old definition of a straight line. It is doubtful whether a navigator would agree with this entirely, but as far as mathematics is concerned this is the meaning usually attached to it in simple geometry. A better definition would be 'a straight line is one which keeps the same direction throughout its length'.

3. *DIAMETER*
The diameter of a circle is a straight line drawn through the centre and terminated at both ends by the circumference. Any diameter cuts a circle into two equal parts, each being called a semi-circle. The angle in a semi-circle is a right angle.

4. *CHORD*
An important theorem in geometry states that if a tangent be drawn to a circle and at the point of contact a chord be drawn, then the angles which the chord makes with this tangent are equal to the angles in the alternate segments of the circle.

5. *ASYMPTOTE*
This peculiar word is derived from the Greek language and first appeared in mathematics in 1656. It was used for the name of the line to which a curve continually approaches but does not meet within a finite distance. Frequently an asymptote is called a tangent at infinity.

6. *SECANT*

If a straight line cuts any curve at two distinct points, it is called a secant. The beginner in geometry must always differentiate between a secant and a tangent, for the latter, no matter how far it is produced either way, has only one point in common with a curve.

7. *PARALLEL OF LATITUDE*

This is a small circle drawn through places of the same latitude. It is parallel to the equator and at right angles to the earth's axis or the line joining the North and South poles. Latitudes are expressed in degrees and minutes on either side north or south of the equator.

8. *RADICAL AXIS*

This is the locus or path of a point which moves so that the tangents drawn from it to two fixed circles are equal. Actually it is a straight line perpendicular to the line joining the centres of the two circles.

9. *DIRECTRIX*

The term came into use in 1702. The distance from any point on a conic (ellipse or parabola) to the directrix bears a constant ratio to the distance of the same point from the focus of the conic. For determining the standard equation for a conic the directrix–focus property is generally used.

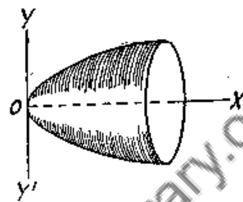
10. *SIMSON or PEDAL LINE*

Robert Simson, professor of Mathematics at Glasgow University in the 18th century, has been honoured by having this particular line of a triangle named after him. He made many contributions to mathematics, and most of the English editions of Euclid are based on his work.

ANSWERS TO QUIZ NO. 18

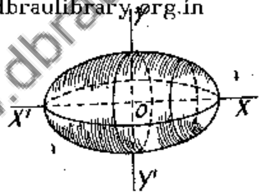
1. *PARABOLOID*

The surface of a solid obtained by revolving a parabola about its principal axis is usually called a paraboloid. In shape it resembles that part of an acorn which lies outside the cupule. The volume of a paraboloid is readily found from the equation of the parabola from which it is generated.



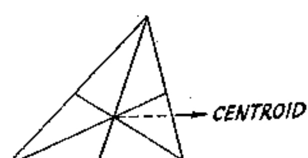
2. *ELLIPSOID*

This solid is normally formed by revolving an ellipse about its major axis. All cross sections of the solid so formed are circles or ellipses. The perfect rugger ball is an ellipsoid, and some birds' eggs are nearly ellipsoidal in shape.



3. *CENTROID*

The three medians (lines from a vertex to the mid-point of the opposite side) of a triangle pass through a common point called the centroid of the triangle. The term did not come into general use until towards the end of the 19th century. It is derived from 'centre' and 'oid'. The centre of gravity of a triangular lamina is at this point.

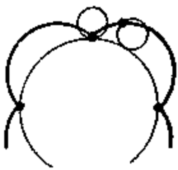


4. *HYPOCYCLOID*

The Greek word 'hypo' means 'under' and the word 'epi' means 'upon'. The hypocycloid is the curve traced out by a mark on the circumference of a circle which rolls on the inside of the circumference of a fixed circle. At every point where the mark touches the fixed circle there is a cusp (a point where two branches of a curve meet). A four-cusped hypocycloid is often called an astroid, and the equation of the curve is less complicated than that of a hypocycloid.

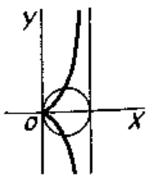
5. *EPICYCLOID*

The curve was so named by Romer in the 17th century. He showed that cog-wheels whose teeth are shaped like an epicycloid curve revolve with minimum friction. If two pennies had been used to trace out the curve by rolling one round the other, then the curve formed would be a cardioid. These curves can be seen as caustics by reflection.



6. *CISSOID*

This curve was discovered by the Greek mathematician Diocles, who flourished as a geometer about 180 B.C. The cissoid was used to accomplish the duplication of a cube, that is, to find the side of a cube whose volume is double that of a given cube. The word is derived from two Greek words meaning 'ivy' and 'form' which suggests that the curve is 'ivy-shaped'. Its shape can be seen by plotting the graph of the equation $y^2(2a - x) = x^3$, and Newton devised a method of constructing it mechanically.



ANSWERS TO QUIZ NO. 19

1. *THREE*
Early linear measurements were defined in terms of body sizes which, of course, vary from man to man! The earliest English law defining length was made during the reign of Edward II in 1324. It read, 'Three barley corns, round and dry, placed end to end, make an inch.' Probably this was more of a standard than the width of a man's thumb.

2. *ASTROLABE*
The name is derived from two Greek words meaning 'star taking', but the instrument can be used to take the altitude of the sun or moon. By the 15th century quite complicated astrolabes were being used by astronomers, but about 1480 a simpler instrument was made for mariners. The mariner had to know the sun's declination from tables and he could then calculate his latitude from his own observation of the altitude of the mid-day sun using the astrolabe. This instrument did not give accurate results and in the 18th century it was superseded by Hadley's sextant. The maximum angle which could be measured by Hadley's sextant was 90°, hence it was sometimes called a quadrant.

3. *NOCTURNAL*
A nocturnal is an instrument which was used for finding the time by night by observing the relative positions of the Pole Star and the pointers of the Great Bear. In the British Museum can be seen a nocturnal made by Humfray Cole in 1560. This instrument was not difficult to use and when the movable arm was adjusted so that the two pointers of the Great Bear appeared to lie on it the time could be read off from a time disk graduated in hours and minutes. The nocturnal was replaced by the chronometer at sea, but was used until quite late in the 18th century.

4. *HERO OF ALEXANDRIA*
The exact period of Hero's work we do not know, but he belonged to the 'First Alexandrian School'. We do know

that he was an able mathematician. About 80 B.C. he put engineering and surveying on a more scientific basis. He is given the credit for discovering this formula for the area of a triangle where 's' = half the sum of the sides of the triangle.

5. *PENTACLE*

The pentacle looks like two interlaced triangles. The pentacle and the pentagram are the same figure. It was used as a symbol of mystery by the Greeks, and various societies have used this same symbol. In the Middle Ages many people considered the pentacle to be powerful in keeping away evil spirits.

6. *PLANIMETER*

This instrument is used for mechanically measuring the area of an irregular plane figure. The hatchet planimeter is probably the simplest type and the wheel and disk or Amsler type is the most common.

7. *FRUSTUM*

Frustum means 'a piece broken off'. It can be used to refer to that portion of a regular solid left after cutting off the upper part by a plane parallel to the base, but it can also be used to describe the portion intercepted between any two planes.

8. *APPROXIMATING AN AREA*

The area is divided into any even number of parallel strips of equal breadth.

9. *CUBE*

A hexahedron is a solid figure which has six faces, so that the regular hexahedron is a cube, for it has six equal faces.

10. *ELEVEN SECONDS*

Six strikes and five silent spaces between the strikes. These take five seconds—a second a space! Therefore eleven spaces in striking 'twelve' will take eleven seconds.

ANSWERS TO QUIZ NO. 20

1. *PYTHAGORAS* *'a gorsy path'*
He is one of the best-known mathematicians of the ancient world. He lived in the 6th century B.C. After his studies he went to Crotona, a Greek city in Italy, and there founded a 'school' of wealthy men. Pythagoras included geometry as an essential part of education. Many of the discoveries of his pupils were attributed to Pythagoras. There is no doubt that this Greek philosopher had a great influence. The Pythagoreans were dispersed for political reasons and Pythagoras died in exile.

2. *PLATO* *'to lap'*
He was born in 429 B.C., became a pupil of Socrates, and after spending much time in travel returned to Athens to form a school for students called the 'Academy'. He was a philosopher and made a study of geometry compulsory before the study of philosophy. It is said that over the entrance to the school was inscribed, 'Let no one ignorant of geometry enter.' Plato is not associated with any well-known theorems or proofs but he introduced system and method into mathematics.

3. *LEONARDO* *'rod alone'*
Leonardo of Pisa, or Leonardo Fibonacci, after travelling in Arabia, returned to Italy and in 1202 published a book explaining the Arabic number system. Obviously this was much more practical than the Roman system with the result that it came into general use amongst merchants. Leonardo must be given the credit for this achievement. Algebra, geometry, and trigonometry were also dealt with by this mathematician from Pisa.

4. *GALILEO* *'a gel oil'*
He is sometimes known as the father of dynamics. Galileo was born in Pisa in 1564. The incident referred to in the question took place in the cathedral of Pisa. He timed

the swings of a large hanging lamp and noticed that no matter whether the oscillations were large or small, the time of swing was the same. He did the timing by using his pulse.

5. *PASCAL* *'a clasp'*
Blaise Pascal was a contemporary of Descartes. When quite young he displayed a natural aptitude for geometry and very quickly mastered Euclid. He made his reputation both as a philosopher and as a mathematician. He is responsible for much of the original work on the theory of probability as well as the properties of the cycloid. When nineteen years of age he made the first calculating machine, and in 1649 was given the royal right to manufacture the 'machines à calculer'.

6. *BARROW* *'rob war'*
Isaac Barrow, who lived from 1630 to 1677, was a much-travelled man. He was educated at Charterhouse, Felstead, and Cambridge. He was elected a Fellow of Trinity College, Cambridge, in 1649. He held many positions of importance in the academic world—Professor of Greek at Cambridge, Professor of Geometry in Gresham College, a Fellow of the Royal Society. He was the first Lucasian Professor of Mathematics at Cambridge but later resigned this post in favour of his brilliant pupil, Isaac Newton, whose superiority he recognized. Barrow became Master of Trinity College, and later was elected Vice-Chancellor of the University of Cambridge. In 1660 he was ordained a clergyman, and continued to urge his conviction that God was ever present and eternal and that there was a divine nature about space and time which accounted for the certainty of mathematics.

7. *NEWTON* *'not new'*
Isaac Newton, who lived from 1642 to 1727, is the greatest of all English mathematicians. In an attempt to assess his achievements it seems to be impossible to exaggerate! Many

mathematicians of other nations maintain that he was the greatest genius of all time.

8. *ARGAND* *'rag and'*

Jean Robert Argand wrote on the graphic representation of $\sqrt{-1}$, but his work did not at first attract attention. The Argand diagram, which provides a frame of reference for graphing complex numbers, honours this French mathematician.

ANSWERS TO QUIZ NO. 21

1. *KNOT*
The log was used to find the speed of a ship. A thin quadrant of wood was weighted to float upright and fastened to a line wound on a reel. Pieces of knotted string were fastened to the log-line and the number of these knots which ran out while the sand-glass was running gave the speed of the ship in knots, or in nautical miles per hour. A nautical mile is 6080 feet.

2. *DRAWING OR BOOK PAPER*
Paper is sold in different sizes and some peculiar-sounding names are to be heard in the trade. One common term for writing-paper is Foolscap. Printing paper may be called Royal or Imperial, according to size. The following names are used for drawing and book papers—Royal, Imperial, Elephant, Double Elephant, and Antiquarian. The Elephant size is 23 in. × 28 in. and the Double Elephant is $26\frac{1}{2}$ in. × 40 in.

3. *SLATES*
Slates are used for roofing buildings of every description. The better slates can resist fire and water. They vary in colour from blue to green and are cut in different sizes. The common sizes are 'large ladies' (16 in. × 8 in.), 'countesses' (20 in. × 10 in.), and 'duchesses' (24 in. × 12 in.).

4. *TIMBER*
Pine and spruce timber is sold by the standard hundred or load. The Leningrad standard is common and consists of 120 pieces, each with the dimensions 6 ft. × 11 in. × 3 in., so that the volume of wood in a Leningrad standard hundred

$$= 120 \times 6 \times \frac{11}{12} \times \frac{3}{12} \text{ cu. ft.}$$
$$= 165 \text{ cu. ft.}$$

The London, Leningrad, and Christiania standard hundreds all have 120 pieces but of different dimensions.

5. *HERRINGS*

Much has been written about the exact capacity of a cran. The word is probably derived from a Gaelic word, and a 'cran' is fixed at $37\frac{1}{2}$ gallons and contains about 750 fish.

6. *FLOWER-POTS*

Garden pots are frequently counted by the 'cast' but in recent years a firm usually quotes the cost per 1000. The number per cast varies, but for the common sizes there are 32 of $6\frac{1}{4}$ in., 24 of $7\frac{1}{2}$ in., 16 of $8\frac{1}{2}$ in., and 12 of 10 in. The cast represents the work done by a hand-thrower in half an hour, and a hand-thrower's output is about 20 casts a day.

7. *WOOD*

A cord is a measure of wood. This suggests that wood was possibly measured by the use of a cord. The measurements of this volume of wood are 8 ft. × 4 ft. × 4 ft. high.

8. *GAS*

The 1948 Gas Act in Britain established Area Boards which were responsible for the fixing of tariffs. Gas is sold by the therm or 100,000 B.T.U. (British Thermal Units), e.g. the cost of a therm is about 25 pence.

9. *TUN*

Before 1707 there were disputes over the volume of a wine-gallon. An Act of Parliament of that year fixed it as 231 cu. in. At the same time it was decided that a tun should be 252 wine-gallons.

10. *ELECTRICITY*

To make the requisite charge for the supply of electrical energy to a house or building, meters are fixed in the consumer's circuit. The meter measures the energy in kilowatt-hours (K.W.H.) or Units. The Unit of electrical energy costs about one penny.

ANSWERS TO QUIZ NO. 22

1. *Q. E. D.*
This is the abbreviation for 'Quod erat demonstrandum', a Latin phrase which can be translated as in the question. This dates back to the time when all mathematics books were written in Latin. In the geometry books today these letters appear at the end of each theorem. Placed at the end of each problem are the letters Q.E.F., standing for 'Quod erat faciendum', which means 'Which was to be done'.

2. $\cos\theta$
All trigonometrical ratios of angles are abbreviated. These are written $\sin\theta$, $\cos\theta$, $\tan\theta$, $\operatorname{cosec}\theta$, $\sec\theta$, $\cot\theta$. The cosine of an angle is the ratio of the base to the hypotenuse of the right-angled triangle. Some people remember these different ratios by means of this mnemonic 'Some People Have, Curly Brown Hair, Till Painted Black'.

3. $f(x)$
As an example, $x^2 + 2x - 7$ depends for its value on the value given to x, and it is therefore called a function of x and is written f(x). If $f(x) = 3x - 5$, and if x is given the value 3, then $f(3) = 3.3 - 5 = 9 - 5 = 4$.

4. $\int 16x^3dx$
$\int$ is called the operator and shows that the operation of integration is to take place on $16x^3$, and dx makes it clear that the integration is to be with respect to x. $\int 16x^3dx = 4x^4$. If $4x^4$ were differentiated we should obtain $16x^3$. Integration and differentiation are two processes closely related to each other.

5. *L. C. M.*
This is the mathematical shorthand for lowest common multiple. Thus the L.C.M. of 4, 8, and 12 is 24, because 24 is the smallest whole number into which 4, 8, and 12 will divide exactly.

6. *sinh x*

The functions $\frac{1}{2}(e^x - e^{-x})$ and $\frac{1}{2}(e^x + e^{-x})$ possess properties analogous to sin x and cos x. These functions are therefore defined as 'hyperbolic sine' and 'hyperbolic cosine' of x. $\sinh x = \frac{1}{2}(e^x - e^{-x})$, and $\cosh x = \frac{1}{2}(e^x + e^{-x})$. Just as $\sin^2 x + \cos^2 x = 1$, so $\cosh^2 x - \sinh^2 x = 1$.

7. *i*

If $x^2 = -1$, then we can find no real number to satisfy the equation. The Swiss mathematician, Euler, introduced the symbol i for $\sqrt{-1}$. The symbol is used when dealing with 'complex numbers'. It is also essential when studying both the theory of airflow patterns and alternating currents.

8. *H. C. F.*

This is the abbreviation for 'highest common factor'. Thus 3 is the H.C.F. of 6, 9, and 12. It is usual to find the H.C.F. by writing down the prime factors of each number and noting those that are common to all.

9. $\frac{dy}{dx}$

This is the differential coefficient of y with respect to x, or the first derivative of y with respect to x. It can also be considered to be the gradient of the tangent to the graph of y plotted against x. If $\frac{dy}{dx}$ is constant at different points along the graph then the graph is a straight line; if $\frac{dy}{dx}$ varies then the graph is a curve.

10. *e*

The eccentricity of a conic is the ratio between the distance of a point on the curve from the focus and the distance of the same point from the directrix. The following values for e are always true: $e < 1$ for the ellipse, $e = 1$ for the parabola, and $e > 1$ for the hyperbola.

ANSWERS TO QUIZ NO. 23

1. *ASTRONOMY*
The science of star-arranging or classifying seems to narrow down astronomy, but the subject matter of astronomical science includes all the matter of the universe which lies outside the limit of the earth's atmosphere. Such a vast subject is subdivided, and the mathematician can come into his own with celestial mechanics.

2. *ARITHMETIC*
The word 'arithmetic' is derived from a Greek word meaning 'the art of counting' which in turn comes from another Greek word meaning 'number'. The scientific treatment of numbers with the Greeks had special reference to ratio, proportion, and the theory of numbers. Before algebra was considered to be the subject of a separate study arithmetic embraced all number knowledge including all that we should now term algebra. Perhaps a more modern meaning of the word arithmetic would be 'the art of numerical calculation and its immediate applications'.

3. *TRIGONOMETRY*
The subject of trigonometry deals with the measurement of the sides and angles of a triangle and with functions of their angles. Early theories in astronomy were halted until the invention of trigonometry in the 2nd century B.C. Hipparchus, an eminent Greek astronomer, can be called the father of trigonometry.

4. *GEOMETRY*
The subject first developed was land-surveying, and this took place particularly in Egypt. When the Nile overflowed its banks and flooded the fields, the land-marks were removed. It became essential then to develop a system of surveying. Hence the derivation of the word 'I measure the earth'. In this way we have the origins of the subject. The Greeks were quick to develop the subject in a more abstract way.

It is true to say that all the leading mathematicians have been interested in Geometry.

5. *ALGEBRA*

The first Arabian mathematician of note is Alkarismi (9th century) and he wrote an algebra book entitled *Al-jebr we' l mukabala.* In this book he shows how to treat equations (a) by taking quantities from one side to the other, (b) uniting similar terms into one term. From the word 'Al-jebr' our word 'Algebra' is derived. In the 12th century mathematical works in Arabic were translated into Latin and then Europe possessed the tools for further progress.

6. *MATHEMATICS*

The word 'mathematics' came into use in the late 16th century and it is derived from a Greek word meaning 'something learned' or 'science'. Broadly speaking it is divided into two sections: (1) Pure mathematics, which is the abstract science of space and number, (2) Applied mathematics which, as its name implies, deals with the application of mathematics to all branches of science and engineering.

7. *STATICS*

In modern use this branch of applied mathematics is concerned with the action of forces in producing equilibrium or rest, in contrast to dynamics, which deals with the action of forces in producing motion.

8. *CALCULUS*

This word came into use in 1672, and is derived from the fact that calculations were made on an abacus with the aid of small stones or pebbles. There will always be arguments as to whether Newton or Leibnitz invented the calculus. It is now accepted that Newton was the first inventor and Leibnitz did not 'borrow' his ideas! We actually use the notation originated by Leibnitz.

ANSWERS TO QUIZ NO. 24

1. *ABACUS*
About 2000 years ago merchants would count by setting out pebbles in grooves of sand. The Romans set out pebbles in grooves in a metal plate. Such were the early models of the calculating frame. The type of abacus with sliding balls on wires came into use in England in the late 17th century.

2. *CLEPSYDRA*
This name is derived from two Greek words, and the device was designed by the ancients to measure time by the discharge of water. The water-clock was used by Egyptians more than 3000 years ago, but better models were made by the Greeks about 400 B.C. Such a device enabled people to tell the time at night.

3. *TALLY*
The tally or the tally stick was a piece of wood scored across with notches for the items of an account. The size of the notch varied from the small pence notch to larger ones for a shilling and a pound and so on. The stick was then split into halves of which each party kept one. Hence we see the derivation of the term 'our accounts tally'.

4. *FRENCH CURVE*
Accurate curves are essential in engineering drawing. Circles are drawn with special compasses. For other curves a French curve is used, a portion of this being selected to fit the curve to be drawn.

5. *SEXTANT*
This astronomical instrument includes a graduated arc equal to a sixth part of a circle, and it is used in particular for observing altitudes of celestial bodies in order to fix a latitude at sea. The instrument was first described to the Royal Society by Robert Hooke in 1667.

6. *THEODOLITE*

The origin of this useful instrument is not known. It was originally used for measuring angles in a horizontal plane. The essential parts are a horizontal plane and two 'sights' such as are found in an alidade. With the telescope came better models, and further improvements came with levels, verniers, micrometers, and a vertical scale.

7. *SLIDE-RULE*

John Gunter invented a slide-rule in 1620. A logarithmic scale was marked on a single line and by means of dividers multiplications and divisions could be worked out by adding and subtracting lengths on the scale. Two Gunter's scales arranged to move side by side were more practical and were soon incorporated in the design.

8. *ADDING MACHINE*

The adding machine was invented by Pascal in 1642 when he was nineteen years of age and he received royal permission to be the only maker in France. The adding machine was modified by Leibnitz to include multiplication. Improvements were made in the 19th century and difference machines soon followed.

9. *CROSS HEAD*

This consists of two pieces of wood at right angles to each other. It is used to ensure that accurate offsets are made from a survey line when making a field survey.

10. *SCREW GAUGE*

This instrument enables one to measure with great accuracy very small lengths placed between metal jaws. One of the jaws is the end of a fine screw which has a pitch of 1 mm. A scale drawn round the head of the screw is divided into 100 parts so that a difference of 0·001 cm. can easily be read.

ANSWERS TO QUIZ NO. 25

1. *CURSOR*

The cursor is defined as a part of a mathematical instrument, which slides backwards and forwards. Newton suggested a cursor or runner should be used on a slide-rule but his idea was not taken up for 100 years. It is obvious when one is trying to read the graduations on two different scales that some convenient straight line is necessary, and the cursor is now an essential part of any slide-rule.

2. *MUSICAL SCALE*

From our childhood we are accustomed to 'doh, ray, me, fah, soh, lah, te, doh', which is known as the diatonic scale. Other scales are to be found in Turkish and Persian music! The frequencies of the 8 notes of a diatonic scale are in the following ratio:

$\frac{1}{1} : \frac{9}{8} : \frac{5}{4} : \frac{4}{3} : \frac{3}{2} : \frac{5}{3} : \frac{15}{8} : \frac{2}{1}$ which is the same as

24 :	27 :	30 :	32 :	36 :	40 :	45 :	48	giving the notes
C	D	E	F	G	A	B	C′	

3. *TWICE*

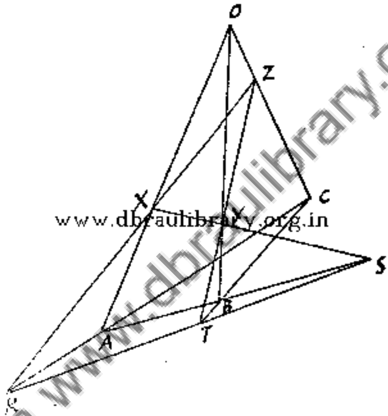
If you doubt this try it by marking the rolling half-crown with a small spot on its circumference. The answer usually given is one, and the false reason supporting the answer is that the circumferences of H and C are the same. However, on doing the experiment you will notice how the spot traces out a special curve.

4. *CYCLOID*

This is the simplest member of the class of curves known as roulettes. It was not known before the 15th century and not seriously studied until the 17th century. So many brilliant mathematicians like Descartes, Pascal, Leibnitz, the Bernoullis, and others have investigated the properties of the cycloid that it was sometimes named the 'Helen of Geometers'. It is a matter of opinion whether the curve, like Helen of Troy, is of surpassing beauty.

5. *DESARGUES' ANSWER*

OA, OB, and OC are three concurrent straight lines with X, Y, and Z any points on each respectively. Join CA and ZX and produce them to meet in R. Similarly join AB and XY to meet in S, and CB and ZY to meet in T. Gérard Desargues, a 17th-century French engineer, proved that R, T, and S always lie on a straight line. Hence if you plant your ten tulips in the positions of the ten points A, B, C, X, Y, Z, R, T, S, and O they will be in ten rows of three.



6. *ABOUT THREE INCHES*

The needle moves from the outermost groove to the innermost groove in an arc whose radius is the length of the pick-up arm.

7. *MR. PHILLIPS*

Mr. Henry will earn during the 1st year £1000.
Mr. Phillips will earn during the 1st year £500 + £500 + £100 = £1100.
Mr. Henry will earn during the 2nd year £1000 + £200 = £1200.
Mr. Phillips will earn during the 2nd year £600 + £100 + £700 + £100 = £1500.
Hence it is clear that Mr. Phillips will earn a sum of £400 more than Mr. Henry by the time they have both worked two years. As the years go by Mr. Phillips will earn increasingly more than Mr. Henry.

ANSWERS TO QUIZ NO. 26

1. $\frac{2}{15}$

The two relevant equations are: $B + C = \frac{2}{5}$

and $B = 2C$

From these we derive that $3C = \frac{2}{5}$ or $C = \frac{2}{15}$.

2. $20\frac{20}{87}$ yards.

A runs 1760 yards whilst B runs 1740 yards and C runs 1720 yards.

$\therefore$ B runs 1740 yards whilst C runs 1720 yards.

$\therefore$ B runs 1760 yards whilst C runs $\frac{1720 \times 1760}{1740}$ yards.

or $1739\frac{67}{87}$ yards.

$\therefore$ B beats C by $20\frac{20}{87}$ yards in a mile.

3. 60 *DAYS*

(A + B) do $\frac{1}{10}$ of the work in 1 day.
(A + C) do $\frac{1}{12}$ of the work in 1 day.
(B + C) do $\frac{1}{20}$ of the work in 1 day.
Add these all together and we have:
$\therefore$ 2(A + B + C) do $(\frac{1}{10} + \frac{1}{12} + \frac{1}{20})$ of the work in 1 day,
or (A + B + C) do $\frac{7}{60}$ of the work in 1 day,
but (A + B) do $\frac{1}{10}$ of the work in 1 day.
$\therefore$ C alone does $(\frac{7}{60} - \frac{1}{10})$ of the work in 1 day,
or C alone does $\frac{1}{60}$ of the work in 1 day.
$\therefore$ C can do all the work in 60 days.

4. 18

A scores 50 whilst B scores 40
B scores 50 whilst C scores 40

$\therefore$ B scores 40 whilst C scores $\frac{40 \times 40}{50}$

or 32.

$\therefore$ A scores 50 whilst B scores 40 and whilst C scores 32.
$\therefore$ A can give 18 points to C.

5. £500

The profit should be shared in the following proportions between A, B, and C: 1875 : 1500 : 1250

$$\text{or} \quad 15 : 12 : 10$$

$$\text{or} \quad \frac{15}{37} : \frac{12}{37} : \frac{10}{37}.$$

$\therefore$ C's share of the profit should be $\dfrac{£10 \times 1850}{37}$

or £500.

6. $1\frac{11}{19}$ *HOURS*

In 1 hour A fills $\frac{1}{2}$, B fills $\frac{1}{3}$, and C empties $\frac{1}{5}$ of the cistern.

$\therefore$ with all the pipes working $(\frac{1}{2} + \frac{1}{3} - \frac{1}{5})$ or $(\frac{19}{30})$ of the cistern is filled in 1 hour.

$\therefore$ with all the pipes working $\left(\dfrac{30}{30}\right)$ of the cistern is filled in $\left(\dfrac{30}{19}\right)$ hours.

ANSWERS TO QUIZ NO. 27

1. $X = 9$, $Y = 1$, $Z = 8$

Examine the units column. $X + Y + Z = 10 + Z$, which means that $X + Y = 10$. Examine the tens column. $X + Y + Z + 1$ (from the units column) $= 10 + X$, which means that $Y + Z = 9$. Examine the ten-thousands column and the equation obtained is: $X + Y + Z + 1$ (from the thousands column) $= 10Y + X$. Substitute $Y + Z = 9$, and the equation then becomes: $10 = 10Y$, or $Y = 1$. From this it follows that $Z = 8$, and $X = 9$.

$$\begin{array}{r} 9999 \\ 1111 \\ 8888 \\ \hline 19998 \\ \hline \end{array}$$

2. $X = 5$, $N = 2$, $P = 1$, $S = 0$, $R = 6$, and $Z = 3$

Examine the second row of multiplication by X. X times X gives another X. $\therefore$ X must be 0, or 1, or 5, or 6. $X \neq 0$ because the product is not XXX. $X \neq 1$ because the product is not PNX. $X \neq 6$ because there is no product of NX by X which will give ? NX. $\therefore$ $X = 5$, because $25 \times 5 = 125$ or $75 \times 5 = 375$. $\therefore$ $N = 2$ or 7. Examine the first row of multiplication by N. $N \neq 7$ because the product is not one of four figures. $\therefore$ $N = 2$. The remainder of the unknown letters follow fairly easily from this stage.

$$\begin{array}{r} 125 \\ 25 \\ \hline 250 \\ 625 \\ \hline 3125 \\ \hline \end{array}$$

3. $P = 3$, $H = 1$, $I = 2$, and $L = 5$

From the first division it is clear that $H = 1$. From the third division L times L gives another L in the units place. $\therefore$ L must be 0, or 1, or 5, or 6. $L \neq 0$ because the product is not LL. $L \neq 1$ because the product is not IL, and in any case $H = 1$. $L \neq 6$ because whatever value is given to I, between 2 and 9, the product of 6 times I6 will not be 1I6. $\therefore L = 5$. $\therefore$ HIL now reads 1I5. Examine the third division again. 5 times I5 is < 200. $\therefore$ I must be 2 or 3. Examine the second division. In order to produce the product 5S, 2 times 25 would be possible and 3 times 35 impossible. $\therefore I = 2$ and $S = 0$. The other letters are easily decoded from this stage.


```
25)3125(125
   25
   --
    62
    50
    --
    125
    125
    ---
    ...
```

4. $A = 3$, $E = 9$, $F = 6$, $H = 0$, $L = 7$, $N = 1$, $P = 2$, and $Y = 5$

By a similar argument as in answer three Y must be 5 or 6. From the second subtraction in the units column $L - H = L$, $\therefore H = 0$. From the second division, in order to produce 0 in the units column, F must be even if $Y = 5$ and F must be 5 if $Y = 6$. From the second subtraction in the tens column $P - N = N$. $\therefore P = 2N$. $\therefore N \not> 4$, and P is even. From the first subtraction in the units column $L - Y = P$. As Y is 5 or 6 the only values P can have must be 2 or 4. $\therefore$ N must be 1 or 2. Now consider F and Y again, trying $F = 5$

and Y = 6 in the second division. An impossible result is obtained so that F must be even and Y = 5. Examine the first subtraction. E − L = P and L − Y = P. By adding these E − Y = 2P. $\therefore$ E = 2P + 5. $\therefore$ P = 2. $\therefore$ L = 7. This is the key and the remaining letters follow quickly.

$$
\begin{array}{r}
35)19775(565 \\
175 \\
\hline
227 \\
210 \\
\hline
175 \\
175 \\
\hline
\ldots
\end{array}
$$

ANSWERS TO QUIZ NO. 28

1. *TYCHO BRAHE*

He was the famous 16th-century Danish astronomer. It was as a result of his systematic observations of the sun and the planets that Kepler discovered his three laws. Mathematically Tycho Brahe's conception of the solar system was the same as that of Copernicus. His approximation of π was 3·1409, but it is not known how Tycho Brahe arrived at this curious value. He perfected the art of astronomical observation before the advent of the telescope, and included in his instruments was a large mural quadrant. The size of the quadrant was so great that it took twenty men to transport it to its operating site!

2. *THALES*

He was the founder of the earliest Greek school of mathematics and philosophy. He was born at Miletus in Asia Minor about 640 B.C., went as a merchant to Egypt, and there he studied astronomy and geometry. Tradition says that he was the first to find the height of a pyramid by means of the shadow-stick method.

3. *ARCHIMEDES*

This famous Greek mathematician and inventor was born at Syracuse in Sicily. His greatest work was done in geometry. He was killed by a Roman soldier when Syracuse was captured in 212 B.C., but he was given an honourable burial. His tomb was marked by a sphere inscribed in a cylinder, for Archimedes considered that his greatest discovery was that both the volume and the surface area of the sphere are two-thirds of the corresponding measurements of the circumscribing cylinder.

4. *DESCARTES*

René Descartes is regarded by some as the father of modern philosophy. In mathematics also this brilliant 17th-century scholar achieved lasting fame. He published in 1637 the first book of co-ordinate geometry. The great advance made by Descartes was the plotting of points to form a curve by using two axes at right angles.

5. *PTOLEMY*

We know little about Claudius Ptolemaeus except that he lived in the 2nd century A.D., in Alexandria, and that he was an astronomer and a mathematician. His great book was translated into Arabic and it is from the Arabic that we get its title *Almagest*. The work is divided into 13 books, and it is obvious to anyone studying these books that Ptolemy was a great geometrician. The suggested coat of arms is the figure for Ptolemy's theorem found in geometry books.

6. *GUNTER*

Edmund Gunter was born in Hertfordshire in 1581. He was appointed professor of astronomy at Gresham College and became a noted inventor and able mathematician. Gunter's chain, devised in 1610, is used in land-surveying. It is 66 feet or 22 yards in length and is divided into 100 links. It has an obvious advantage as far as English square measure is concerned for 10 square chains equal 1 acre.

7. *KEPLER*

His three laws have given this German astronomer great renown. Johann Kepler became associated with Tycho Brahe and when the latter died Kepler had access to his many astronomical observations. From these he discovered the laws which govern the motions of the planets. He found out that the movements of Mars could only be accounted for if the sun was at the focus of an ellipse and the path taken by the planet was the ellipse itself.

8. *GALILEO*

Galileo Galilei was born in the Italian town of Pisa which is noted for its leaning tower. This well-known scientist and astronomer was appointed professor of mathematics at Pisa in 1589. Two years later he performed the experiments which have earned him the title 'Father of Dynamics'. Aristotle had taught that heavy bodies fall faster than lighter ones, and one can imagine the excitement when a young professor proved this to be nonsense! The experiments were performed in front of a large crowd, and for the purpose the famous leaning tower was used.

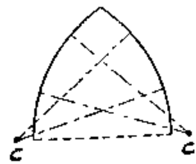
ANSWERS TO QUIZ NO. 29

1. *OGEE*

The Ogee arch is constructed as in the diagram. This type of arch became especially popular in the 14th century in Italy, but owing to its weakness it could only be used in the windows of a church. The points C in this and the other diagrams represent the centres of curvature of sections of the arch.

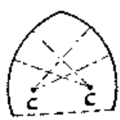
2. *LANCET*

The Lancet arch is composed of two arcs. The centres of these arcs are situated on the springing line produced and outside the arch itself. You will notice that Lancet windows were popular in the early 13th century when two or more of them were placed close together to secure as much light as possible.



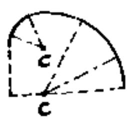
3. *MOORISH*

This is a pointed arch consisting of two arcs but it differs from the Lancet type in that the centres for describing the arcs lie within the opening of the arch itself. This architectural feature appeared for the first time in the 9th century in a mosque in Cairo, and soon became an emblem of the Mohammedan faith. The Moors in North West Africa did not use it.



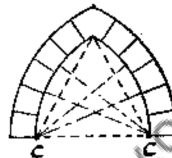
4. *RAMPANT*

The Rampant arch has as a special feature springing points at different levels, but this is essential because the arch is used to support a flight of steps which may be solid.



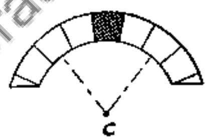
5. *EQUILATERAL*

This type is constructed on an equilateral triangle as in the diagram. This arch was popular in the late 13th century and you will notice that it is much wider than the Lancet type. This arch is sometimes called the Early English or Pointed Arch.



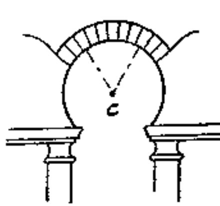
6. *SEGMENTAL*

As its name implies, the Segmental arch is formed from the segment of a circle. The Romans are really responsible for the introduction of arched construction work. In the Segmental arch we have a wonderful example of how bricks can be arranged in a curved structure so that they give mutual support to one another.



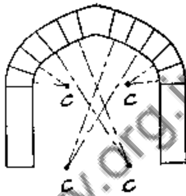
7. *HORSESHOE*

The arc of the Horseshoe arch is greater than a semi-circle, with its centre above the springing line of the arch. This arch was widely employed in Moorish architecture. It was the Horseshoe arch which the Moors brought into Spain, where they built amongst other things the Great Mosque at Cordova. The arch was copied by the French in the south and ultimately a few doorways and windows were decorated by it in England towards the end of the 12th century.



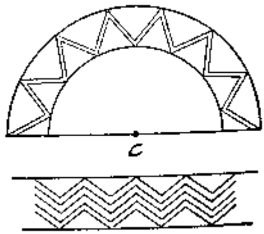
8. *FOUR-CENTRED (TUDOR)*

This arch was first made in the building revival which came with the Tudors and so it is sometimes called the Tudor arch. It is formed by using the arcs of four circles, and is a much stronger and wider arch than the Ogee arch. The builders of churches of this period had to provide large east windows so that the Four-centred arch was the perfect answer.



9. *NORMAN*

The so-called Norman period dates from 1066 to 1189. The Normans were great builders and after the Conquest many church buildings were erected. It is a common mistake to think that a semi-circular arch in a church is necessarily of Norman construction. The pillars, mouldings, or ornamentations must be examined. The plain zig-zag ornamentation called the Chevron is frequently found on the Norman arch. Saxon arches were semi-circular but their mouldings, if present, were very plain.



ANSWERS TO QUIZ NO. 30

1. *T*
The line which touches a circle is called a tangent.

2. *T*
A score is 20. The 20th letter of the alphabet is T.

3. *O*
0 times 123 is 0, which looks like O.

4. *O*
This is an A.P. (Arithmetical Progression) with a common difference of —3.

5. *S*
The sum of the sides of a triangle is denoted by 2s.

6. *M*
The standard unit of length in the metric system is the metre.

7. *P*
Pythagoras.

8. *U*
This is a quadratic equation.

9. *R*
R represents the rate of interest per cent per annum.

10. *H*
The area of a triangle $= \frac{1}{2}$ Base $\times$ Height.

Hence the letters are in the order TTOOSMPURH and these when rearranged form the name PORTSMOUTH.

ANSWERS TO QUIZ NO. 31

ACROSS

1. *FIBONACCI*. Leonardo Fibonacci (or the son of Bonacci or filius Bonacci) was the first man to bring and explain the Arabic system of numbers to Europe. He was a great champion in the popular mathematical tournaments of the 13th century. He wrote both an arithmetic and a geometry book.

2. *CURE*. During the year 1658 it is said that Pascal was suffering from toothache when the idea occurred to him of writing the geometry of the cycloid. He began the work and the pain disappeared, so he continued and completed it in 8 days.

3. *BRAC*. Brackets has 8 letters—omit the last 4.

4. *YU*. YOU minus O equals YU!

5. *OD*. Strange is ODD. ODD curtailed is OD!

6. *AS*. The recognized abbreviation for anna, one-sixteenth of a rupee.

7. *LILEO*. Possibly a twice-beheaded Galileo would have been a simpler clue.

8. *B A*. In all the Tripos examinations the degree is Bachelor of Arts or B.A., although one might expect a B.Sc. in mathematics or science.

9. *I E*. This is the abbreviation for 'id est', the Latin for 'that is'.

10. *LB*. The abbreviation for the pound derived from the Latin 'libra', meaning 'pound'.

11. *R R.* Robert Recorde, who wrote *The Whetstone of Witte*, an algebra book in 1557.

12. *KG.* 1000 grams is a kilogram, and is the commonest unit used in France. It is equivalent to 2·2 pounds weight.

13. *ARCHIMÈDE.* This is the way in which 'Archimedes' is spelt in French.

DOWN

3. *BOOLE.* A 19th-century English mathematician who for many years was professor of mathematics at Cork. He wrote many books. His treatise on the calculus of *Finite Differences* is a classic.

14. *IVORY.* Sir James Ivory was really a self-taught mathematician who lectured at the Royal Military College with great success. Much of his work was published in various journals.

15. *ODD*

16. *ARC*

17. *CHORD*

18. *MACLAURIN.* As a lad he was a good geometer and as a young man he occupied a chair of mathematics at Aberdeen. Later he was recommended by Newton to Edinburgh. He wrote a treatise on *Fluxions* in which the method of distinguishing between 'Max and Min' points on a curve was first given. Maclaurin's Theorem is of the greatest use in expanding certain functions.

19. *RECTANGLE*

20. *EULER*. He was considered a genius even by the Bernoullis. Curiously he was appointed to a chair of mathematics in Russia. He was a prolific writer, not only on mathematical subjects but also on scientific and medical subjects.

21. *TALLY*. Scores in village cricket matches were often kept by cutting notches on a piece of wood. This was done as recently as 80 years ago. The word is derived from the French word 'tailler', meaning 'to cut'.

22. *SIR*. Isaac Newton was knighted on 16th April, 1705.

23. *M P H*. Miles per hour.

24. *CAM*. The river at Cambridge.

25. *L S D*. Pounds, shillings, and pence.

ANSWERS TO QUIZ NO. 32

1. *AN AID FOR READING A NUMBER*

Tonstall, who became Bishop of London during the early part of the 16th century, gave some interesting information about the 'new' Hindu-Arabic number system and arithmetic in England. In his book *De Arte Supputandi* he shows place value by means of stops or points above the figures. We have become used to commas being placed in such a way as to group the figures in threes. Hence $56\dot{7}34\dot{2}452$ is now written as 567,342,452.

2. *PREPARATION TO FIND THE SQUARE ROOT*

Tonstall in his arithmetic book includes a method of finding the square root of a number. Just as we mark off in pairs from the decimal point, he does the same thing but shows it by means of the superior point placed over the first figure in each group. Thus $9\dot{8}5\dot{2}5\dot{4}76$ is the same as $\overline{98}\,\overline{52}\,\overline{54}\,\overline{76}$ or as 98′52′54′76.

3. *MULTIPLICATION OF* 9 *BY* 6

Robert Recorde's arithmetic book *The Grounde of Artes* was the arithmetic book of the century (1543–1643). In this book he gives the rule for multiplying 6 by 6 up to 9 by 9. In the question we have to multiply 9 by 6. A large cross is drawn and the 9 and the 6 are written on the left-hand side. Subtract each from 10 to give 1 and 4 respectively. Now multiply the two differences together, 1 by 4 = 4 and this is the units figure in the answer. Subtract either the 4 from the 9 or 1 from the 6 (that is why the cross is drawn) and then we have the tens figure which is 5. So the answer is 54. We wonder if it isn't easier to learn your tables.

4. *DIVISION BY* 10

Recorde suggested a vertical line to show the division when a number was divided by ten.

5. *DIVISION OF VULGAR FRACTIONS*

Another process shown by Recorde is the multiplication and division of fractions. In division, which we choose in this question, there is no rule about turning the divisor upside down and multiplying. The division is carried out by cross-multiplying. Cross-multiply the 1 and 4 for the numerator and the 3 and 3 for the denominator.

6. *WRITING A DECIMAL*

83 4′ 2″ 5‴ is the same as 83·425. A commercial arithmetic was published by Francesco Pellos in Turin in 1492 and in it he unwittingly used the familiar decimal point. Later writers however used a bar to represent the decimal point. John Napier, the inventor of logarithms, used the style as in the question but later changed this. There must have been at least a dozen methods of writing decimals and today 23·45; 23.45; and 23,45 are used in different countries.

7. *MULTIPLICATION*

This example is taken from John Bonnycastle's book *The Scholar's Guide to Arithmetic*, which was published in 1780. The first line of multiplication is done by 5 feet and the second line by 4 inches. It does work out, and can you unravel this puzzle? Do you pity the scholars of those days? You will notice that linear measure is used throughout the example but that in stating the answer square measure is given. Try this for yourself in any way you wish and you will find that the answer given by this method is nearly correct. It is 19 square feet and $6\frac{2}{3}$ square inches!

8. *RULE OF THREE or PROPORTION*

If 5 books cost 25 shillings, what will 8 books cost? The 5 and the 8 being of the same kind (books) are placed on the same side, and the 25 shillings is placed opposite the 5 because they are linked together. The rule as stated by Recorde is to multiply 8 by 25 and divide by 5 and hence the cross line!

ANSWERS TO QUIZ NO. 33

1. *NO*
You know how difficult it is to match a button when one is lost from a coat or frock! In England fortunately there is a set of standard button-sizes and this concerns the diameter of the button. A button of 1 inch diameter is called a 40-line button, so that a 30-line button is $\frac{3}{4}$ of an inch across. Likewise a 60-line button is $1\frac{1}{2}$ inches across. The sizes range from 12 to 70 lines. The 30-line button is the usual size for a man's suit.

2. *NO*
'Cotton count' is the standard term used to describe the thickness of the yarn. The number of 840-yard hanks required to weigh 1 pound gives the cotton count. For instance if in 1 pound there is

1 hank or	1×840	yards:	the count number is	1 (thick)
2 hanks ,,	2×840	,,	,, ,, ,, ,,	2 . .
24 ,, ,,	24×840	,,	,, ,, ,, ,,	24 . .
50 ,, ,,	50×840	,,	,, ,, ,, ,,	50 (thin)

Consequently as the number of the count increases so the cotton becomes thinner and thinner.

3. $11\frac{2}{3}$ *INCHES*
With the mass production of ready-made shoes in the 19th century came the necessity of standardizing the shoe-size scale. The scale was based on earlier scales which can be traced back to the 17th century. The size interval is now $\frac{1}{3}$ of an inch (one barleycorn) in the length of the shoe but it has not always been $\frac{1}{3}$ of an inch. 4 sizes to 1 inch has been considered. The sizes range from 0 to 13 for boys and then straight to size 1 for men.
Size 0 = 4 inches, and thus size 13 (boys) = $(4 + \frac{13}{3})$ in. = $8\frac{1}{3}$ inches.
Size 10 (men) = $(8\frac{1}{3} + \frac{10}{3})$ in. = $11\frac{2}{3}$ inches.
There is no difference between children's, men's, and women's sizes.

4. *THE COLLAR SIZE IN METRIC MEASURE*

Collar sizes are measured by length, in inches in England and in centimetres on the continent of Europe. 15 in. = 38·1 cm.

5. *NO*

The size of a hat in England is found by taking the average of the largest length from back to front and the greatest width, both reckoned in inches. These measurements are easily found with a hard hat like a bowler. A size 7 in England is the same as a size $7\frac{1}{8}$ in America.

6. *THICKNESS*

These 'numbered sizes' ranging from 2/0 to 32 are quoted on the labels of boxes of wood screws. The 'numbered size' is taken from the Standard Wire Gauge size from which these screws were made. The number on the left-hand side gives the length of the screw and the 'numbered size' appears on the right-hand side of the label.

7. *NO*

A size 16 knitting needle (or pin!) has a diameter of 0·064 in. whilst that of a size 8 needle has 0·160 in. In England all knitting needles of whatever material they are constructed conform to the Standard Wire Gauge (S.W.G.) sizes. This method of describing the size probably dates from the introduction of the steel wire needle which goes back to the last century. The larger the S.W.G. number, the smaller is the diameter of the wire. In the U.S.A. there is a special range of gauge numbers and they indicate the diameter of the needle in millimetres. Many metal knitting needles are now made of an aluminium alloy.

8. *DENIER*

The denier denotes the size or 'count' of the nylon threads. The denier was formerly a small French coin which in the

16th century was worth $\frac{1}{12}$th of a sou. These coins were used to act as weights when testing the fineness of silk fibre in the centres breeding silkworms. At a conference in Paris (1900) the denier system was fixed as 1 denier = 1 gram per 9000 metres of fibre, so that a stocking made of 15 denier fibre would weigh 15 grams for every 9000 metres of fibre used in its manufacture.

ANSWERS TO QUIZ NO. 34

1. *SEVEN*
They are the Pyramids, the Mausoleum at Halicarnassus, the Hanging Gardens of Babylon, the Temple of Diana at Ephesus, the Colossus of Rhodes, Jupiter's Statue by Phidias and the Pharos at Alexandria.

2. *THREE*
Three sisters, daughters of Zeus. Their names are Euphrosyne, Aglaia, and Thalia. They were bosom friends of the Muses and Goddesses of Beauty and Grace who distributed joy and gentleness. Usually they were pictured as embracing each other, showing that where one is, there also are the others.

3. *FOUR*
The same as in an English pack of cards. There is le roi de cœur, le roi de pique, le roi de trèfle, and le roi de carreau.

4. *SIX HUNDRED AND SIXTY-SIX*
The reference is to chapter 13 verse 18 of the 'Revelation of St. John the Divine'. 'Let him that hath understanding count the number of the beast . . . and his number is Six hundred three score and six.' In spite of efforts down the ages to find the beast, it is now accepted that the beast lived in the age when the book was written, and that he was Nero.

5. *NINE*
There are 9 Muses, the 9 daughters of Zeus and Mnemosyne. They were supposed to be the Goddesses of Memory, but later they were identified with the Arts and Sciences. Their names are Calliope (the chief), Clio, Euterpe, Thalia, Melpomene, Terpsichore, Erato, Polyhymnia, and Urania. Clio is associated with history, Terpsichore with song and dance, and Urania with astronomy. Originally there were only three and they were worshipped on Mt. Helicon. Then the number grew to 7, and later to 8. Finally 9 became established throughout Greece with the names given here.

6. *TWO*

The Two Gentlemen of Verona was first printed in the folio of 1623 as the second of the Comedies of William Shakespeare. The names of the two characters in the play are Valentine and Proteus.

7. *FOUR*

Aristotle taught that there were four elements, namely fire, air, water, and earth. Later a fifth was added called 'quintessence', and this was supposed to be in the four other elements and its purpose was to unify them. Shakespeare writes in *Twelfth Night* this sentence, 'Does not our life consist of the four elements?' The modern definition of an element is totally different. Today there are 100 known elements and there is a possibility that more will be discovered.

8. *FIVE*

This is a quotation from *The Owl* by Tennyson. There are five wits—common sense, imagination, fantasy, estimation, and memory. Common sense is the outcome of the five senses, and it appears that Tennyson had in mind the five senses when he wrote these lines.

9. *ONE HUNDRED*

When Napoleon escaped from Elba in 1815 he came to the Tuileries. This was on the 20th of March. It was not until 100 days had elapsed on the 28th of June that Louis XVIII was restored as monarch. The quotation in the question is taken from the address of the Prefect of Paris which he made to the returning King. One very important event which took place during the 100 days was the Battle of Waterloo.

10. *SEPT*

This proverb means 'You must think before you speak'. Probably the English equivalent is 'Count ten before you speak'.

ANSWERS TO QUIZ NO. 35

1. *RECKONING, NUMBER*
The word logarithm is derived from two Greek words. 'Logos' means 'reckoning' and 'arithmos' means 'number'. There is a distinct possibility that Napier took the word 'logos' to mean 'calculation' as in the English word 'logistic'. Hence 'logarithm' can be said to mean 'number calculation'.

2. 2
The logarithm of a number is the power to which the base must be raised to equal the number, or writing this in the form of an equation:

$$\text{NUMBER} = (\text{BASE})^{\text{LOGARITHM}}$$

But we know that $16 = 4^2$
which means that the logarithm of 16 to the base 4 is 2.
This expression is written $\log_4 16 = 2$.

3. *YES*
Isaac Newton was born on the 25th of December 1642 and he died on the 20th of March 1727. In 1614 a book in Latin was published in which the discovery of logarithms was recorded. An English translation of this book appeared in 1615 and tables of logarithms to the base e were published in 1619. Within a year tables of common logarithms were also published.

4. *NAPIER AND BÜRGI*
The Scots would recognize John Napier, Baron of Merchiston, as the first to discover or invent logarithms. The Swiss would be equally emphatic that Joost Bürgi, a Swiss astronomer and a friend of Kepler, should be given the honour of being the inventor. There is little doubt that the idea behind this wonderful aid to calculation was made quite independently by these two mathematicians early in the 17th century.

5. *BRIGGS*

Henry Briggs was educated at Cambridge but became professor of mathematics at Oxford in 1620. He said with reference to Napier's book introducing logarithms that he never saw a book which pleased him more. Briggs could see that if the base of logarithms were 10 and not e then a greater simplification would result and the new logarithms would be of greater practical value. He set to work and published in 1624 his *Arithmetica Logarithmica*, giving the common logarithms of 30,000 numbers. These logarithms were extended to 14 places of decimals!

6. *DUTCH*

Adrian Vlacq of Leyden supplemented Briggs' table of common logarithms. Apparently Briggs had included in his tables only logarithms from 1 to 20,000 and from 90,000 to 100,000. Vlacq filled in the gap between these numbers, so that the 1628 table contained the logarithms of all the numbers from 1 to 100,000.

7. *NAPIER*

The full name of the *Descriptio* is *Mirifici Logarithmorum Canonis Descriptio*. This book was published three years before the death of John Napier in 1617. It contained his table of logarithms with the rules for its use, but there was no account of the construction of the table. The construction was explained in a work published after Napier had died. It is interesting to know that Briggs consulted Napier about the compilation of the new tables to the base 10, and that Napier had already thought of the practical possibility of such a table.

8. *MULTIPLY BY* $LOG_{10}e$

Natural logarithms may be converted into common logarithms by multiplying by a factor called the 'modulus' of the common system of logarithms. This 'modulus' is $\log_{10}e$ or $\dfrac{1}{\log_e 10}$ which has a value of 0·43429448 . . .

9. *SLIDE-RULE*

This is a mathematical instrument used for calculations. The figures on each part of the instrument are spaced out in length according to the logarithms of their values. The modern slide-rule consists essentially of two scales, which are marked on pieces of wood, one of which can slide along the other. The process of multiplication is thereby reduced to one of addition of lengths, and this is easily done by means of the sliding scales. The modern instrument can be used for many different types of calculations, and is much more complicated than the original design by William Oughtred.

10. *GREATEST LOG 2 + LOG 4, LEAST LOG 6 − LOG 3*

$\log(2+4) = \log 6$
$\log 2 + \log 4 = \log(2 \times 4) = \log 8$
$\log(6-3) = \log 3$
$\log 6 - \log 3 = \log(6 \div 3) = \log 2$

Log 8 is the greatest and log 2 is the smallest of these values.

ANSWERS TO QUIZ NO. 36

1. *RIGHT*
The answer is not correct according to Willie's way of thinking—merely to reverse all the numbers is not the correct way.

2. *RIGHT*
Again it is the right answer but the wrong way. Will it happen once more?

3. *RIGHT*
$\sqrt{5\frac{5}{24}} = \sqrt{\frac{125}{24}} = \sqrt{\frac{25 \cdot 5}{24}} = 5\sqrt{\frac{5}{24}}$

4. *RIGHT*
$\sqrt[3]{2\frac{2}{7}} = \sqrt[3]{\frac{16}{7}} = \sqrt[3]{\frac{8.2}{7}} = 2\sqrt[3]{\frac{2}{7}}$

5. *RIGHT*
Willie is correct this time but does he realize why this is so? His conclusion does not necessarily follow from the first part of the question. He does not use the word 'therefore' correctly.

6. *RIGHT*
He succeeds in obtaining the answer, but $\sin(a + b)$ does not equal $\sin a + \sin b$! In fact $\sin(a + b) . \sin(a - b)$ should be $\sin^2 a . \cos^2 b - \cos^2 a . \sin^2 b$ and the solution follows from here.

7. *RIGHT*
You will notice that you are given two equations to find two unknowns, and Willie uses only one of them. Also he writes in error that $\frac{x - 1}{y} = \frac{x}{y} - 1$. Finally, although $\frac{x}{y} = \frac{5}{6}$ it does not follow that $x = 5$, and $y = 6$, there are many other possibilities!

8. *RIGHT*
No working is necessary here—just count the number of triangles.
Although Willie's work shows consistently correct answers, there is an amazingly incorrect use of 'therefore' in writing and by symbol! In the first four examples it is essential to show the working. Perhaps he has worked his examples properly on a piece of scrap paper, or perhaps he has just guessed.

ANSWERS TO QUIZ NO. 37

1. 120

This is an illustration of the multiplicative principle. In this case there are 12 ways of choosing the head boy. With each of these ways it is possible to choose the head girl in 10 ways. The particular girl who is chosen is not determined by the choice of the head boy. The choice of each is made independently and in succession so that the total number of possibilities is the product of the two possibilities.

2. 720

This may seem a big number of arrangements. It is the product of $6 \times 5 \times 4 \times 3 \times 2 \times 1$. Another way of writing this product is $\underline{|6}$, or, as it is often printed, 6!. It is called factorial 6. In this example, the left-hand boy can be any one of them, so there are 6 ways of choosing him. The next boy from the left-hand side can be chosen in 5 ways from the remaining 5 boys. The next boy in 4 ways, the next boy in 3 ways, and so on. If there were 8 boys altogether (only two more) the number of possible arrangements would be 8! or 40,320. If there were 10 boys then there would be more than three million ways of arranging them.

3. 120

This is not the same answer as in the last question because it is only the order which is considered and not the actual position. There will be 6 positions in which the same order will be found but each position will be turned round relatively to the other. Another way of considering this problem is to keep one boy always in the same place and then arrange the remaining 5 boys. This can be done in 5! ways or 120. Any order arranged clockwise has an equivalent order arranged anti-clockwise. The number of 120 different ways includes both these as separate arrangements. It is considered that sitting on a person's right is different from sitting on his left. These two arrangements are mirror images of one another.

4. $26 \times 25 \times 24 = 15600$

This is called a 'permutation of 26 different letters taken 3 at a time' and is written in mathematical language as ${}_{26}P_3$. It is fairly easy to see how one arrives at this calculation. Expressed in terms of factorials it is the result of dividing factorial 26 by factorial (26 — 3). In general the number of permutations of n things if only r are taken at any one time is ${}_nP_r$ or factorial n divided by factorial (n — r).

5. $3 \times 3 \times 3 \times 3 = 3^4 = 81$

Consider each game separately. The first game may be won, lost, or drawn by one of the teams. Therefore there are 3 possibilities in this result. For each one of these first-game possibilities the second game has 3 possibilities. This makes 9 possible forecasts for the first two games. For each of these 9 forecasts the third game has 3 possibilities and so on. Hence for four games there are 81 different forecasts possible. If you are absolutely certain of the result of one of these games then you need only make $3 \times 3 \times 3$ or 27 forecasts to ensure that amongst them is one complete correct forecast. If you can 'bank' on two results (i.e. have two 'bankers') then you need only make 3×3 or 9 forecasts to ensure you have one correct forecast of all the four games.

6. 36

The argument is the same as in the last question. The first die may fall in 6 different ways and with each of these ways there are 6 possibilities for the second die. The total scores range from 2 to 12.

7. 1728

What difficulty the captain will have in deciding the order of rowing in the boat for his crew if he has so many possibilities! This number 1728 can be obtained in several ways. Consider the stroke-side men first: the fourth oarsman can be chosen from the 3 who can row on either side in 3 ways; when this fourth oarsman is chosen the four stroke-side oarsmen can be arranged in 4! ways; therefore there are 3 × 4! ways of arranging the stroke side. Now consider the bow-side oarsmen. There is no choice of men. There are 2 bow-side oarsmen and 2 who can row on either side. These can be arranged in 4! ways. For each stroke-side arrangement any one of the bow-side arrangements is possible. Thus the total number of arrangements is $3 \times 4! \times 4!$, which is 1728.

ANSWERS TO QUIZ NO. 38

1. 39 *DAYS*
During the last and fortieth day the pond which was half-covered becomes completely covered—just doubled in one day!

2. 1 *GALLON*
A volume has three dimensions and each is doubled according to the question. Hence the new volume is $2 \times 2 \times 2$ times the original volume.

3. *LONDON*
The train leaving Oxford travels the faster, so naturally they meet and cross one another nearer to London. In fact, the meeting place is $\frac{40}{90}$ of 60 or $26\frac{2}{3}$ miles from London, and $\frac{50}{90}$ of 60 or $33\frac{1}{3}$ miles from Oxford, and this happens at 10.40 a.m.

4. (a) 15, (b) 7, (c) 21
(a) The numbers in this series double themselves for each new term.
(b) These numbers are the cubes of the natural numbers.
(c) Each number in this series is 5 greater than the previous number.

5. (a) 9, (b) 16, (c) 20
(a) Each term in this series is $\frac{1}{3}$rd of the previous term.
(b) These numbers are the squares of the natural numbers.
(c) These numbers are 1×2, 2×3, 3×4, 4×5, 5×6, . . .

6. *SIX*
The centres of the surrounding coins lie on a circle of radius equal to the diameter of the coin. The centres form the corners of a regular hexagon.

7. I, II, III, IIII, V, VI
The usual way of writing 4 in Roman numerals is IV.

ANSWERS TO QUIZ NO. 39

1. *SPAIN*
1 Peseta = 100 Centimos. Notes and coins are available. The rate of exchange is approximately 110 pesetas to the pound sterling.

2. *THAILAND or SIAM*
1 Baht = 100 Satang. The baht was previously called a tical. British troops captured in Singapore and who went to Siam were familiar with the tical.

3. *AUSTRIA*
1 Schilling = 100 Groschen. The tourist counts a schilling as an English threepence, for 73 schillings = £1 sterling.

4. *GREECE*
1 Drachma = 100 Lepta, and £1 sterling = 84 drachmae.

5. *JAPAN*
1 Yen = 100 Sen, and £1 sterling is worth 1010 yen.

6. *PORTUGAL*
1 Escudo = 100 Centavos. Each escudo is worth an English threepence, for 80 escudos will buy £1 sterling.

7. *ITALY*
£1 sterling is equivalent to 1755 lire.

8. *PERU*
1 Sol = 100 Centavos. 53·50 soles equal £1 sterling.

9. *BURMA*
1 Kyat is worth about 1 shilling and 6 pence in English money.

10. *BULGARIA*
1 Leva = 100 Stotinki. £1 sterling is equivalent to 19 levas.

ANSWERS TO QUIZ NO. 40

1. **d** This is derived from the Roman word 'denarius'. British money had its origin in Roman times when 1 libra (pound) = 20 solidi, and 1 solidus = 12 denarii. Hence £ s. d.

2. **n** This product is known as 'factorial n' or 'n factorial'. It is sometimes written as $\underline{|n}$, but n! is easier to print.

3. **a** As in the alphabet so in both A.P. and G.P. 'a' is the first term.

4. **d** Circumference is π times the diameter, or $C = \pi.d$.

5. **n** This is the abbreviation for 'number'.

6. **u** Final velocity is always 'v' and the letter immediately preceding in the alphabet, 'u', is used for the initial velocity.

7. **e** This is the base of natural logarithms.

8. **r** These numbers form a G.P. whose common ratio is 3. The letter used to represent common ratio is 'r'.

9. **l** This is the abbreviation for 1000 cc. or 1 litre.

10. **s** This is used as it is the initial letter of the word 'space'. Distance is the space covered or travelled.

Hence the letters form the anagram DNADNUERLS which when rearranged give the word SUNDERLAND.

ANSWERS TO QUIZ NO. 41

1. 1 6 15 20 15 6 1

These numbers are obtained by adding together the figures found on the left hand and the right hand immediately above the dashes.

2. 9 36 84 126 126 84 36 9

The extreme numbers on either side of the line are both 1. The other numbers are obtained as explained in the answer to question number 1. In exactly the same way line after line can be added indefinitely to the triangle.

3. *THIRD AND FOURTH LINES*

The full expansions are:

$(x + a)^2 = 1(x^2) + 2(ax) + 1(a^2)$

$(x + a)^3 = 1(x^3) + 3(ax^2) + 3(a^2x) + 1(a^3)$

The numbers or the coefficients of the terms in this type of expansion are readily obtained by the direct application of the Binomial Theorem which states that:

$$(x + a)^n = x^n + nx^{n-1}a + \frac{n(n-1)}{1.2}x^{n-2}a^2 + \frac{n(n-1)(n-2)}{1.2.3}x^{n-3}a^3 + \text{etc., etc.}$$

4. 1 8 24 32 16

The numbers in the fifth line of the triangle are 1, 4, 6, 4, 1. $\therefore$ the expansion of $(x + 2)^4 = x^4 + 4(x^3 2) + 6(x^2 2^2) + 4(x2^3) + 2^4$. From this the coefficients as above are derived. Both the coefficients and the actual terms are found by substituting $a = 2$ and $n = 4$ in the Binomial expansion stated in the last answer thus:

$$(x + 2)^4 = x^4 + 4x^3 2 + \frac{4.3}{1.2}x^2 2^2 + \frac{4.3.2}{1.2.3}x2^3 + \frac{4.3.2.1}{1.2.3.4}x^0 2^4$$

$$\therefore (x + 2)^4 = x^4 + 8x^3 + 24x^2 + 32x + 16$$

5. *PASCAL*

Pascal contributed much written work to mathematics and included in this is a paper on the arithmetical triangle. Hence the name 'Pascal's triangle'. Other mathematicians—Tartaglia (1560), Schenbel (1558), and Bienewitz (1524) had used this to determine the coefficients in a binomial expansion, but they had not dealt with the arrangement as thoroughly as Pascal did in his *Traité du triangle arithmétique* printed in 1654.

6. 15 *MAGIC SQUARE*

A magic square is an arrangement of numbers such that the sum in each row, each column, and each diagonal is the same. The earliest magic square dates back to about 2200 B.C. and no doubt it was familiar to the Chinese then. Late in the 15th century a treatise on magic squares appeared in Italy. The squares were arranged in 'orders' and one can appreciate why magic properties at this time became associated with these squares. Some of them engraved on precious metals could bring long life and prevent disease!

7.

16	2	12
6	10	14
8	18	4

To obtain the missing numbers first find the total of the top row or the left-hand column. This equals 30. Then calculate the centre number from the diagonal. The rest follow easily from this point.

8.

1	15	14	4
12	6	7	9
8	10	11	5
13	3	2	16

This is a magic square using all the numbers 1 to 16 only. It is formed from a basic square in which all these numbers are included written in order left to right across each row in turn. All the numbers cut by both diagonals are retained but all the others are interchanged with their diametrically opposite numbers.

ANSWERS TO QUIZ NO. 42

1. 1., 1.2, 1.2.3, 1.2.3.4, 1.2.3.4.5, . . .
Each term in this series is a factorial, which means the product of all the numbers from 1 to the particular term considered. The first five terms of this series are thus: 1, 2, 6, 24, 120, and the sum of these is 153.

2. *HERE THEY ARE*:
$$\frac{2}{4} = \frac{3}{6} = \frac{79}{158}, \quad \frac{3}{6} = \frac{9}{18} = \frac{27}{54}, \quad \frac{2}{6} = \frac{3}{9} = \frac{58}{174}.$$

3. 1 lb., 3 lb., 9 lb.
The key to this problem is that the barrow-boy can put any combination of weights on either pan and the difference between the two weights is the amount of fruit he sells. Thus the weight he requires is the result of an addition or subtraction sum.
$1 - 0 = 1$, $3 - 1 = 2$, $3 - 0 = 3$, $(3 + 1) - 0 = 4$, $9 - (3 + 1) = 5$, $9 - 3 = 6$, $(9 + 1) - 3 = 7$, $9 - 1 = 8$, $9 - 0 = 9$, $(9 + 1) - 0 = 10$, $(9 + 3) - 1 = 11$, $(9 + 3) - 0 = 12$, and finally $(9 + 3 + 1) - 0 = 13$.

4. *YES*
$$\frac{9}{\sqrt{9} \times \sqrt{9}}, \quad \frac{9}{9} + \sqrt{9}, \quad \frac{9}{\sqrt{9}} + \sqrt{9}.$$

5. *NORTH POLE*
Yes, and there are other places too! These are the places on a parallel of latitude in the southern hemisphere which lies 100 miles north of a parallel of latitude that has a total length of 100 miles. Can you puzzle this out?

6. 264 feet, 880 yards

60 miles per hour	=	88 feet per second.
∴ Length of train	=	88 × 3 feet,
	=	264 feet.

To pass completely through the tunnel the train must travel for a time of 30 seconds.

∴ Length of tunnel	=	88 × 30 feet,
	=	880 yards.

ANSWERS TO QUIZ NO. 43

1. *THE SIGN FOR EQUALITY*
There is little doubt that the parallel lines of one length, =, which is the sign for equality today, was due to Robert Recorde. In his book *The Whetstone of Witte*, written in 1557, he clearly states why he introduced the symbol. Other symbols did exist until the 18th century, but we must admit that 'no two things can be more equal' than these two lines.

2. π
In the 16th century there appeared to be an urge by mathematicians to calculate the value of π to many places of decimals. Ludolph (or Ludolf) van Ceulen gave the value of π to some 20 places of decimals in 1596. A few years later he had worked out the ratio to 35 places. Hence the reason why π was called in German textbooks the 'Ludolphische Zahl'.

3. *ALGEBRA*
Towards the close of the 15th century Lucas Pacioli, a Franciscan friar, published a mathematics book in Venice. Like the Arabs before him he called the unknown quantity the 'thing' (we of course use the letter 'x'). The Italian word for 'thing' is 'cosa'. Hence we see why the old name for algebra in England was the 'Cossic art' or the 'Rule of Coss'.

4. *PRIME NUMBERS*
Eratosthenes was a contemporary of Archimedes and both were educated at Alexandria. He constructed an instrument to duplicate a cube and gave a laborious method of constructing a table of prime numbers. The latter is called the 'Sieve of Eratosthenes', and as one bright pupil said, 'If any composite number gets through that sieve then the age of miracles is not passed.'

5. *A PARTICULAR DIVISION OF A LINE*

If you draw any line AB and then find a point C in it such that $\frac{AB}{AC} = \frac{AC}{CB}$, then the line AB is cut in the golden section at the point C. This section is used in art and it is pleasing to the eye to see a composition on canvas where the golden section has been intentionally or intuitively applied.

6. *MORE THAN ONE POSSIBLE SOLUTION FOR A TRIANGLE*

If you are given two sides of a triangle and an angle opposite one of them, it is very likely that two triangles can be found which will fulfil these conditions. For instance, if $a = 100$ ft., $b = 224$ ft., and angle $A = 30°$, then if you solve the triangle one solution is possible where angle B is less than 90° and another where angle B is greater than 90°.

7. *SUNDIAL*

The style is the pin, rod, or triangular plate which forms the gnomon of a sundial. A pupil of Thales, the founder of the first Greek school of mathematics, is said to have introduced the use of the style or gnomon into Greece. Simple sundials have been found in Pompeii.

8. *CHECKING MULTIPLICATION AND ADDITION*

This method of 'casting out the nines' was introduced nearly a thousand years ago by the Arabs. Nines are 'cast out' of each factor in the multiplication equation. The remainders are then multiplied and nines are 'cast out' again. If the remainders at this stage are unequal the equation is false. It does not follow that if the remainders are equal the equation is true! Example: Let us find out if this multiplication is false.

$$7926 \times 3487 = 27{,}637{,}862.$$

'Cast out' the nines and the remainders are:

$$6 \qquad\quad 4 \qquad\qquad\quad 5$$

Multiply the remainders:

24 5

'Cast out' the nines again and the remainders are:

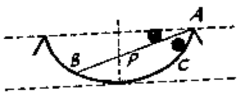
6 5

These remainders are unequal, therefore there is a mistake in the equation. Actually the answer should be 27,637,962. If this process of 'casting out the nines' had been applied in the same way to the product 27,637,692 then the error would not have been detected. Thus the process has only a limited application.

The same process of 'casting out the nines' can be used to check for mistakes in the addition of numbers.

9. *ARC OF A CYCLOID*

The question refers to the well-known brachistochrone problem or the curve on which a body descending to a given point under the action of gravity will reach it in the shortest time. The Bernoullis are responsible for the name of the problem. At first sight it does seem amazing that a steel ball will roll from one point to a lower point on a cycloidal-shaped bowl in a quicker time than it will roll down a plane joining the two points. Refer to the diagram—the steel ball will roll down from A to B more quickly along path C than it will along path P.



10. *JAPANESE ABACUS*

The name of the instrument is sometimes spelt with an O thus: soroban. It is very similar to the Chinese abacus known as a suanpan or swanpan. There is no doubt that the Japanese can use their abacus with amazing speed and dexterity. The most complicated sums are worked out with unerring accuracy. The Japanese shopkeepers and clerks become very dependent upon their sorabans for they are used frequently in sums whose answers we should work out mentally.

ANSWERS TO QUIZ NO. 44

1. *HARMONIC PROGRESSION*

This is sometimes abbreviated to H.P. but don't confuse it with a sauce or a horse! If a, b, and c are in harmonic progression then $\frac{1}{a}$, $\frac{1}{b}$, and $\frac{1}{c}$ are in A.P. Thus 1, $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$ . . . form a harmonic progression, for 1, 2, 3, 4 . . . are in A.P. In music, strings of the same material with the same diameter and tension, but with lengths in harmonic progression, produce harmonic tones.

2. *FIBONACCI SERIES*

This series consists of the numbers 0, 1, 1, 2, 3, 5, 8, 13, 21, . . . The sum of the 2nd and 3rd terms equals the 4th term, and the sum of the 3rd and 4th terms equals the 5th term, and so on all the way through the series. This series is named after Fibonacci, who is generally known as Leonardo of Pisa. He was born in 1175. Curiously the leaves on a stalk, petals of some flowers, and lettuce leaves follow the ratios of successive terms of the Fibonacci series.

3. *LET US SEE!*

$$S = 1 + 3x + 5x^2 + \ldots\ldots\ldots\ldots + 39x^{19}$$

$$Sx = x + 3x^2 + \ldots\ldots\ldots\ldots + 37x^{19} + 39x^{20}$$

By subtraction:

$$S(1 - x) = 1 + 2x + 2x^2 + \ldots\ldots\ldots\ldots + 2x^{19} - 39x^{20}$$

$$= 1 + \frac{2x(1 - x^{19})}{1 - x} - 39x^{20}$$

$$= \frac{1 - x + 2x - 2x^{20} - 39x^{20} + 39x^{21}}{1 - x}$$

$$\text{Sum} = \frac{39x^{21} - 41x^{20} + x + 1}{(1 - x)^2}$$

4. (a) 19 . 21 . 23 (b) 28560

In order to find the sum of n terms of this series, write down the last term multiplied by the next highest factor and subtract the first term multiplied by the next lowest factor, and then divide by the product of (the number of factors in each term + 1) and (the common difference of the factors). Obeying these instructions in this particular series we get:

$$\text{Sum} = \frac{19 \,.\, 21 \,.\, 23 \,.\, 25 - 3 \,.\, 5 \,.\, 7 \,.\, 9}{(3+1) \,.\, 2}$$

$$= \frac{229425 - 945}{8}$$

$$= 28560$$

5. *NO*

At first sight this may appear strange, but if we put x = 1 in this series we obtain:

$$\log_e 2 = 1 - \frac{1}{2} + \frac{1}{3} - \frac{1}{4} + \frac{1}{5} - \ldots\ldots\ldots\ldots$$

In order to get the value of the logarithm correct to four places of decimals we should have to consider hundreds of terms of this series. Life is too short for this! Fortunately other series can be deduced from $\log_e(1 + x)$ which are more quickly convergent and hence more useful for the calculation of logarithms.

6. *Sin x*

Both sin x and cos x are functions of x and they can both be expanded in a series of terms which are in ascending powers of x. Using Maclaurin's theorem it is a simple matter to show that

$$\text{Sin}\, x = x - \frac{x^3}{3!} + \frac{x^5}{5!} - \frac{x^7}{7!} + \ldots\ldots\ldots\ldots$$

x in these expansions is measured in radians and not degrees. (π radians $= 180°$). Using this series we can soon work out the value of various sines. For instance, if we put $x = 0{\cdot}2$ in the series we shall find that sin x has a value of 0·1988. Now convert x from radian measure into degrees:

$$x = \frac{0{\cdot}2 \times 180}{3{\cdot}14} \text{ degrees}$$

$$= 11° \, 28'$$

Thus we succeed in calculating that Sin $11° \, 28' = 0{\cdot}1988$.

7. *EXPONENTIAL*

The base of natural logarithms is 'e' and this quantity is the sum to infinity of the series:

$$1 + \frac{1}{1!} + \frac{1}{2!} + \frac{1}{3!} + \frac{1}{4!} + \ldots\ldots\ldots\ldots$$

The peculiarity of this series is that when it is raised to the power x the following series is obtained:

$$1 + \frac{x}{1!} + \frac{x^2}{2!} + \frac{x^3}{3!} + \frac{x^4}{4!} + \ldots\ldots\ldots\ldots$$

and this series is convergent for all finite values of x. This series, which is the expansion of e^x, is known as the Exponential series.

ANSWERS TO QUIZ NO. 45

1. *THALES*

This Greek philosopher lived about 600 B.C. He introduced abstract geometry, and in the process of trying to develop deductive reasoning he collected a number of geometrical facts together. Many discoveries in geometry are attributed to Thales. He differed from some of the Greek mathematicians who came after him because he applied geometry to a number of practical problems.

2. *EUCLID*

He was born about 330 B.C. and was of Greek descent. Euclid is without doubt the most famous of all mathematicians before Newton. He was the author of several works, but one of the world's famous books, the *Elements*, made his reputation. In the 13 books, Euclid collected all the known facts about geometry and it was at once accepted as the standard work. It was translated into Arabic, and came back to Europe in a Latin translation.

3. *APOLLONIUS*

He lived from about 260 to 200 B.C. He studied at Alexandria and probably lectured there. Later he spent some years at Pergamum before returning finally to Alexandria. He is celebrated for a systematic work on conic sections. Apollonius is called the great geometrician. There was evidently no Greek rule that constructions should be done with a pair of compasses and a ruler only, for Apollonius was the first person who definitely stated this requirement.

4. *LEIBNITZ*

Gottfried Wilhelm Leibnitz (or Leibniz) was most catholic in his studies and interests. He is best known for his discovery in the 17th century of the calculus which he did independently of Newton. Leibnitz used the names 'calculus differentialis' and 'calculus integralis', so there is no doubt who was the Father of the names in common use today. He is also responsible for the notation of the calculus.

5. *GAUSS*

Carl Friedrich Gauss was born in 1777 and became a great astronomer as well as a brilliant mathematician. His work *Disquisitiones arithmeticae* was published in 1801 and it is still one of the standard works on the theory of numbers. From a magnetic observatory erected at Göttingen he sent telegraphic signals to a neighbouring town and was the first to show the practicability of the electro-magnetic telegraph.

6. *RECORDE*

Robert Recorde, who studied at Oxford and graduated in medicine at Cambridge in 1545, was the author of *The Grounde of Artes*. This is an arithmetic book and it is one of the earliest mathematical books to be printed in English. The book, published in 1540, 'teaches the work and practice of arithmetic in whole numbers and fractions', and is in the form of a catechism or dialogue. He used the + and the − signs 'to represent too much and too little' respectively.

7. *BERNOULLI*

One of the famous family of Swiss mathematicians was James (Jacob or Jacques) Bernoulli, who was appointed as professor of mathematics at Basle in 1687. He did much to extend the use of the calculus, and he was the first mathematician to publish a work on the integral calculus. In his *Ars Conjectandi* he defines the numbers which are now named after him. They are the numerical values of the coefficients of $\frac{x^2}{2!}, \frac{x^4}{4!}, \frac{x^6}{6!}, \cdots$ $\cdots\cdots\cdots\cdots \frac{x^{2n}}{(2n)!}$, in the expansion of $\frac{x\,e^x}{(e^x - 1)}$.

8. *LAGRANGE*

He is said to have been the greatest mathematician of the 18th century. He was born in Turin and established an

Academy there. He later went to Berlin and finally to Paris as a professor. He made original contributions to mathematics at a very early age and he was a ceaseless writer all his life. His monumental work is the *Mécanique analytique*, in which he deduces the whole of mechanics from one fundamental principle. It was in an earlier work while at Turin that he dealt with the problem of the transverse vibration of stretched strings and he pointed out the deficiencies in earlier solutions and gave the complete solution.

9. *MERCATOR*

He was a Flemish mathematician and geographer who devoted his life to mathematical geography. His great world map was completed in 1569. It is called Mercator's projection and has the parallels and meridians at right angles. Compass bearings can be drawn as straight lines on these maps and since the 18th century this projection has been used for nautical charts. Mercator made maps, globes, and astronomical instruments of wonderful precision considering that they were constructed many years ago. His work was carried on by two of his sons.

10. *AHMES*

The so-called Rhind papyrus which is now in the British Museum was written by a scribe named Ahmes. It is one of the earliest mathematical documents on papyrus existing and dates back some 1500 or more years B.C. It consists of some rules and questions in arithmetic and geometry. The answers are given but not the working. Quite a lot of mensuration is to be found on the Rhind papyrus. It has this name because it was purchased 100 years ago by an English Egyptologist named Rhind. Ahmes is clearly copying an older work, for he writes, 'This book was copied in the year 33,' and the work is headed, 'Directions for knowing all dark things.'

ANSWERS TO QUIZ NO. 46

Across

1. *ADDITIONS.* 'Tot' is the short for 'total' or the Latin 'totum'. It appears to have come into use about 1690.

2. *TRAP*

3. *STAR.* The pointers in the constellation Ursa Major or 'The Great Bear' point to the Pole Star.

4. *RL.* Reversed abbreviation of Latus Rectum, or the chord perpendicular to the axis of the parabola and passing through its focus.

5. *NH*

6. *LV*

7. *APPLE.* This recalls the well-known story of the apple falling from the tree to the ground.

8. *CR.* Abbreviation for 'credit' and typed in black on a bank statement. You are not then 'in the red'.

9. *IN.* Newton carved his initials on a desk in the school he attended at Grantham, Lincolnshire.

10. *LB.* The area equals length times breadth or written in symbols A = l.b.

11. *CM.* The abbreviation for centimetre.

12. *HP.* Horse-Power, which is the unit of the rate of doing work.

13. *MEASURING*

Down

3. *SNELL*. Dutch astronomer and mathematician who was born in Leyden in 1591, where he later became Professor of Mathematics. He discovered the law of refraction in 1621.

14. *DINAR*

15. *INS*. The correct abbreviation for inches is 'in'.

16. *I O U*. This represents 'I owe you' and is the formal acknowledgement of a debt.

17. *NORTH*. When the north direction is marked the plan can readily be orientated.

18. *AUTOLYCUS*. He flourished about 330 B.C. Two Greek works on astronomy exist and are preserved at Oxford.

19. *BAR GRAPHS*. These graphs consist of parallel bars whose lengths are proportional to certain quantities given in a set of tables.

20. *PLANE*

21. *ROPES*. In order to mark out a right angle the Egyptians used knotted ropes to form a '3-, 4-, and 5-sided' triangle.

22. *ONE*

23. *CGS*. The centimetre—gram—second system where these are the fundamental units of length, mass, and time.

24. *BAR*. In order to show a negative characteristic in a logarithm the minus sign is written over the figure.

25. *SIN*. This is the abbreviation for the sine of an angle.

ANSWERS TO QUIZ NO. 47

1. *HISTOGRAM*

Let us suppose that we know the heights of 1000 men picked at random. Tabulate the number of men whose heights lie in the equal ranges between 64 in. and 65 in., 65 in. and 66 in., 66 in. and 67 in., and so on. Plot on a graph the frequency (number of men) in each range against the heights by making a series of columns whose areas are proportional to the frequency. This is a histogram and the diagram above the questions is one such graph.

2. *FREQUENCY POLYGON*

On the histogram mark the mid-points of all the ranges of the variable quantity as shown in the same diagram. Join these mid-points by a jagged line. This is a frequency polygon. When the number of observations is increased considerably this frequency polygon becomes a frequency curve. This is made possible by choosing smaller ranges of the variable quantity and at the same time having a large number of observations in each range.

3. *NORMAL CURVE*

Many variable quantities form this shape of curve as their frequency curve. Some examples are: heights of persons, sizes of shoes worn by people, and intelligence quotients. One of the characteristics of this 'normal curve' is that it is always smooth and symmetrical.

4. *MEAN*

This is what the ordinary person means when he speaks of an average. It is the 'average' of everyday life. It is obtained by adding together all the values of the variable quantity and then dividing this by the total number of these values. In this way we should find, for instance, the average consumption of milk per person per day or the average life span of a horse. Do batting averages work out in this way? What about the batsman's 'not-out'?

5. *MODE*

This is an average often used in statistics. It is the most commonly occurring value in a series of observations of a variable quantity. In a symmetrical frequency curve (or normal curve) the mean and the mode are the same. In the lopsided curve or skew curve they are different.

6. *STANDARD DEVIATION*

Sometimes the observed values of a variable quantity are all close to the mean value. Sometimes they are widely dispersed. The standard deviation tells us the degree to which they are dispersed. This standard deviation, denoted by the Greek letter sigma, σ, is calculated by taking the square root of the deviations from the mean, divided by the total number of observations. Mean error, mean square error and error of mean square are other names for standard deviation. σ^2 is called the variance.

7. *TIME-CHART*

A statistical time-chart may be a number of irregular lines (often called a jagged line graph) or it may be a smooth curve. If the temperature of a sick patient is taken every 12 hours and plotted this produces a jagged line graph. If the temperature of a kettle of boiling water is taken every half-minute as it is allowed to cool in a quiet room the curve produced is a smooth curve.

ANSWERS TO QUIZ NO. 48

1. *EUCLIDE. ARCHIMÈDE. APOLLONIUS DE PERGE*

Surtout pour les raisons sociales, les premiers géomètres étaient passionés de vérité, d'harmonie et de beauté, alors que les applications leur apparaissaient trop vulgaires. Ce fut Aristote qui dit: 'Les sciences pures sont supérieures aux autres.' Il a dit ceci en ces mots: 'la science qui n'a pas de sujet sensible est au dessus de celle qui en a un'.

2. *THOMAS MALTHUS*

Il disait dans son *Essay on Population* en 1798 que seuls des obstacles puissants (misère, contrainte, morale, etc.) opposés à l'accroissement de population, pourraient empêcher les moyens de subsistance de devenir insuffisants. Il comptait sans l'amélioration des moyens de communication et des méthodes de culture!

3. π

Beaucoup de valeurs inexactes de π ont été données. Archimède donnait: 'entre $3 + \frac{10}{71}$ et $3 + \frac{10}{70}$'. Un Hindou au VI^me^ siècle donna 3,1416. Au XVI^me^ siècle Adrien Métius donna $\frac{355}{113}$ (12 décimales exactes). En 1610 127 décimales sont trouvées, et en 1873 William Shanks en trouve 707!

4. *L'INFINI*

Aucun ouvrage grec de mathématiques qui nous soit parvenu ne contient le mot 'infini', et les Grecs n'ont jamais conçu une progression qui eût compris un nombre illimité de termes. Euclide lui-même dut inventer le raisonnement par l'absurde pour éviter de considérer la notion de l'infini.

5. *THALÈS DE MILET*

Thalès est né en 639 avant Jésus-Christ. On peut le considérer comme le créateur de la physique, de l'astronomie, et de la géométrie. Il tenait la terre pour ronde et décrivait la petite Ourse. Il calcula la durée de l'année et demontra le premier l'égalité des deux angles à la base du triangle isoscèle.

6. *IMPOSSIBLE*

Ceci est un postulat. Euclide fut le premier à voir que ce postulat avait besoin d'une preuve, mais celle-ci ne put pas être trouvée. Repousser l'énoncé était absurde, aussi Euclide l'accepta-t-il sans démonstration.

7. *JAMAIS*

Lorsqu'on divise par $\triangle x$ on suppose avant tout qu'il n'est pas nul, car la division par zéro est impossible en algèbre. Tout ce que l'on suppose c'est qu'il est inférieur à n'importe quel nombre, si petit soit-il.

8. *GÉNÉRALEMENT FAUX*

Si le viseur était plus élevé que la lentille on pourrait voir la tête du sujet, tandis que la photo le montre décapité. Cette différence s'appelle la parallaxe, et se manifeste lorsque le viseur et la lentille sont séparés.

ANSWERS TO QUIZ NO. 49

1. *DIRECTOR*
The locus of the intersection of pairs of perpendicular tangents to an ellipse is a circle, and this circle is called the director circle of the ellipse.

2. *AUXILIARY*
The circle which is described with the major axis of the ellipse as diameter is called the auxiliary circle of the ellipse. Unlike the director circle the auxiliary circle will touch the ellipse in two points at the extremities of the longer or major axis. Draw a circle and from a number of points on it drop perpendiculars on a diameter. Divide these perpendiculars in a given ratio (say 2 : 3). The join of these points will form an ellipse with the original circle as the auxiliary circle.

3. *NINE-POINT*
This circle as its name suggests passes through nine points. Six of these points are mentioned in the question and the remaining three are 'the mid-points of the lines between the vertices and the common point of intersection of the altitudes'.

4. *ORTHOGONAL*
Orthogonal means 'right-angled; pertaining to or depending upon the use of right angles'. If any two curves cut at right angles they are said to intersect orthogonally. Such curves are of interest in many branches of applied mathematics. One point of interest about two circles cutting orthogonally is that the square of the distance between the centres is equal to the sum of the squares of their radii.

5. *INSCRIBED*
A circle is said to be inscribed in a polygon when each side is tangential to the circle. Consider the case of the simplest polygon—a triangle. The inscribed circle is obtained by bisecting the angles of the triangle. These bisectors pass

through a common point which is the centre of the inscribed circle.

6. *GREAT*

Any circle on the surface of a sphere whose plane goes through the centre of the sphere is called a great circle. If the earth be considered as a sphere of radius 3960 miles, the great circles passing through the north and south poles are called meridians of latitude.

7. *OSCULATING*

An osculating circle of a curve has three or more coincident points in common with the curve. This term appears to have come into use early in the 18th century. The radius of the osculating circle gives the radius of curvature of a curve. This is usually found by making use of a formula in calculus.

8. *ESCRIBED*

The interior bisector of one angle and the exterior bisectors of the other angles of a triangle are concurrent in a point which is equidistant from one side and the other sides produced of a triangle. Hence a circle can be described to touch one side and the other sides produced. Such a circle is called an escribed circle of the triangle, and every triangle has three escribed circles.

9. *CIRCUMSCRIBED*

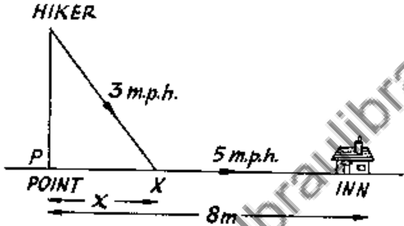
The meaning of 'to circumscribe' is to describe a figure round another so as to touch it at points without cutting it. This is precisely what takes place with the circumscribed circle. To find the centre of such a circle, bisect the sides of a triangle and erect perpendiculars. They are concurrent at the circumcentre. The radius R of the circumscribed circle of the triangle ABC is given by

$$R = \frac{a}{2 \sin A} = \frac{b}{2 \sin B} = \frac{c}{2 \sin C}.$$

ANSWERS TO QUIZ NO. 50

1. $1\frac{1}{2}$ *MILES*

Suppose the hiker strikes the road at X, a distance of x miles from P. Let T be the total time taken by the hiker to reach the inn. It is the time which has to be a minimum to fulfil the conditions of the question.



$$\text{But} \quad T = \frac{(x^2+4)^{\frac{1}{2}}}{3} + \frac{(8-x)}{5}$$

Differentiate T with respect to the variable x:

$$\frac{dT}{dx} = \frac{1}{3} \cdot \frac{1}{2} \cdot \frac{2x}{(x^2+4)^{\frac{1}{2}}} - \frac{1}{5}$$

There is a 'minimum' when:

$$\frac{x}{3(x^2+4)^{\frac{1}{2}}} = \frac{1}{5}$$

or when $5x = 3\ (x^2+4)^{\frac{1}{2}}$

or when $x = 1\frac{1}{2}$ miles.

2. 96 *CUBIC INCHES*

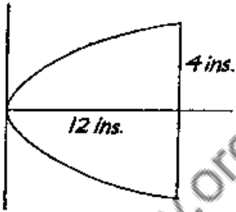
The section of the space-hat is a parabola of the form $y^2 = 4ax$. Substitute one set of known values of the space-hat and we have:

$$y^2 = 4ax$$

$$\text{or } 4^2 = 4a \,.\, 12$$

$$\therefore a = \frac{1}{3}$$

The equation of the parabola is $3\,y^2 = 4\,x.$



By integration we have the volume of the hat thus:

$$\text{Volume} = \pi \int_0^{12} \frac{4}{3} \,.\, x \,.\, dx$$

$$= \pi \left[\frac{4}{3} \cdot \frac{x^2}{2}\right]^{12}_{0} \text{ cubic in.}$$

$\therefore$ Volume $= 96\,\pi$ cubic in.

3. 1152 *CUBIC INCHES*

Let V be the volume of the box.

Let x be the side of the squares cut out.

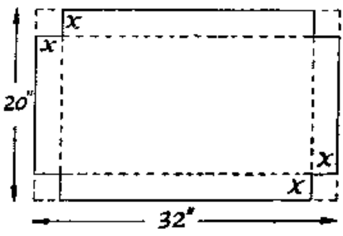
Then $V = (32 - 2x)(20 - 2x)\,x$

or $V = 640x - 104x^2 + 4x^3$

$$\therefore \frac{dV}{dx} = 640 - 208x + 12x^2$$

For a maximum volume, $\dfrac{dV}{dx} = 0$

$$\text{or } 3x^2 - 52x + 160 = 0$$
$$\text{or } (3x - 40)(x - 4) = 0$$
$$\text{or } x = 4 \text{ or } x = \frac{40}{3}.$$



Using the real value of $x = 4$, the maximum volume of the box is $24 \times 12 \times 4 = 1152$ cubic inches.

4. 573 *FEET*

Consider a small angular movement $d\theta$ takes place during a small displacement ds. Then if R is the radius of the circle in which it moves:

$$\frac{1}{R} = \frac{d\theta}{ds}$$

$$\therefore ds = R\, d\theta$$

$$\therefore s = R \int_0^{\frac{\pi}{6}} d\theta$$

$$= R \Big[\theta\Big]_0^{\frac{\pi}{6}}$$

$$\therefore 2 \,.\, 150 = R \,.\, \frac{\pi}{6}$$

$$\therefore \underline{R = 573 \text{ feet.}}$$