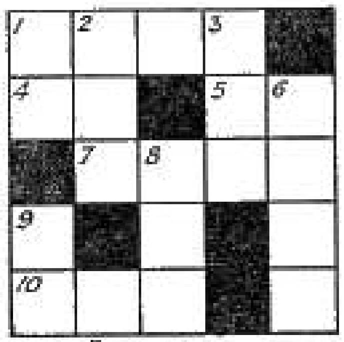
JUNIOR CROSS-FIGURE NO. 19

Suggested by P. Fenner, Form 2A, Lockleaze County School, Bristol.



Across

1. x^2 when $2x/91 = 8/7$.
4. $\dfrac{1{\cdot}85 \times 1{\cdot}722}{{\cdot}259 \times 1{\cdot}5}$
5. Radius of circle given PQ = 9 cm. and QR = 12 cm. (see Fig. 1).
7. Shaded area, in sq. cm., taking $\pi = 22/7$. (See Fig. 2).
10. 1276 yds. as a decimal of 1 mile.

Down

1. The angle through which the hour hand of a clock turns in 7(a—b) minutes. (See 2 down).
2. $2ab^2$ where $7a - 2b = 1$ and $10a - 3b = 3$.
3. H.C.F. of 5247 and 3339.
6. Number of pence in £22.9875.
8. 7/88ths of an acre in square yards.
9. Angle PCQ given that angles RQC and PQC are in the ratio 3 : 17.

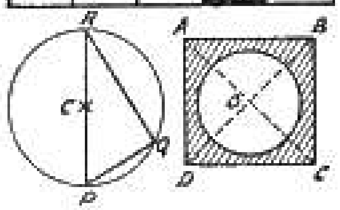


Fig. 1 Fig. 2

ABCD a square of side 400 mm. Radius of circle 175 mm.

Check

The sum of all the answers to all the clues is 8434.8.

I.H.

Solution to Alpha's Aqua: One Quart (2 πnts or 2 pints.)

SOLUTIONS TO PROBLEMS IN ISSUE NO. 20

CURIOUS DIVISION

All through the division you are dividing 9 into numbers whose last digit is 1. After 71, the next highest number ending in 1 is 81, which is itself a multiple of 9; hence you cannot have the figure 8 appearing in the answer.

MATHEMATICAL JIGSAW NO. 3

By joining the vertices of the trapezium to the mid-points of the non-parallel sides you can make four triangles, as shown in the diagrams.

SENIOR CROSS-FIGURE NO. 20

Across: (1) 76s.; (3) 3·79; (5) 5·83; (6) 65 sq. ft.; (7) 31°; (9) 24 cu. yd.; (11) 25; (13) 486 sq. ft.; (14) 5·14 cm.; (15) ·03.
Down: (2) 6552; (3) 3·33; (4) 91; (8) £1260; (10) 444; (12) 15 miles.

CHARLIE COOK NO. 7

The equation $(a - x)(x + b) = c$ can be solved correctly by Charlie Cook's method whenever $c = a + b - 1$. You can verify this by finding the general solution to the equation and equating it with $a - c$ and $c - b$.

JUNIOR CROSS-FIGURE NO. 18

Across: (1) 174; (4) 11 ft.; (6) 2·52 ft.; (7) 13; (8) 1399°; (10) 56; (12) 21; (13) 360; (16) 105; (17) 1·4.
Down: (1) 1225; (2) 75%; (3) 421; (4) 1191; (5) 193°; (9) 320°; (11) 630; (14) £65; (15) 24.

MATHEMATICAL LIMERICK NO. 5

If x^2 is length of beard

$$2x + x^2 - 10 = -2, \text{ i.e. } x^2 + 2x - 8 = 0 \quad \text{i.e. } (x + 4)(x - 2) = 0$$

i.e. Beard was 2 ft. long.

EDITOR'S NOTE

Our readers may be interested to know that copies of some of the past issues are still available. Nos. 1 to 4, 13, 15, 16 are unavailable; some other issues are scarce. Write to Editorial Office, 97, Chequer Road, Doncaster.

46767 83744 94482 55379 77472 68471 04047 53464

MATHEMATICAL PIE

NUMBER TWENTY-ONE *Editorial Offices:* 97 Chequer Road, Doncaster. MAY 1957

MATHEMATICAL INSTRUMENTS NO. 3

The Astrolabe—Part I

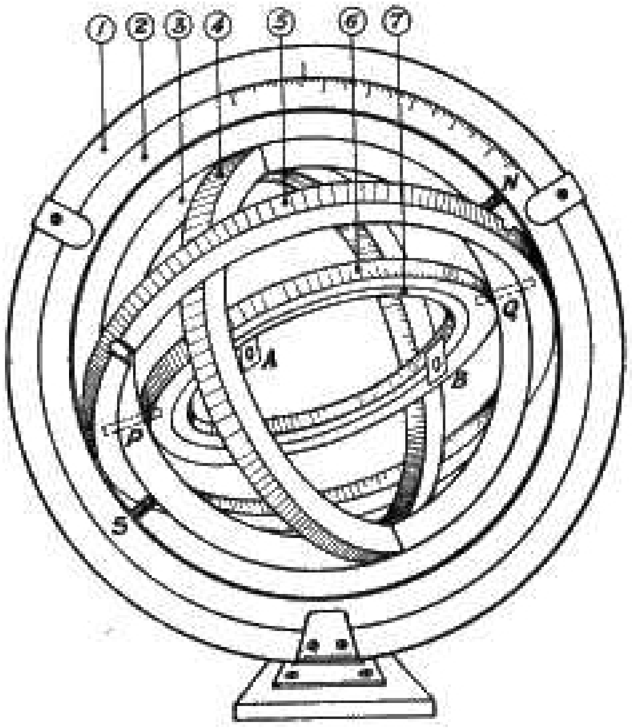
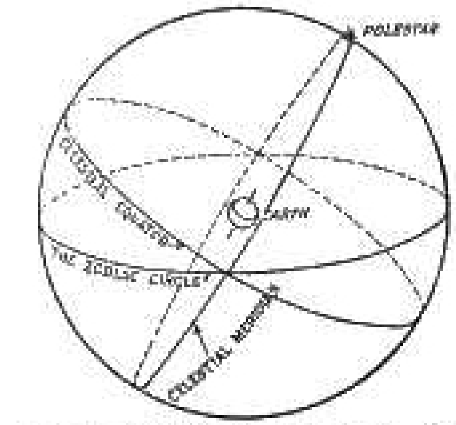


Fig. 1.



To an observer on the Earth, the fixed stars seem to be attached to a sphere which revolves round the Pole Star once in 23 hours 56 minutes. The Sun appears to move slightly slower in front of a belt of stars called the Zodiac Circle. The Moon and planets move on paths near this Circle. The Celestial Equator is an imaginary circle midway between the celestial poles. The Celestial Meridian is a circle through the poles passing through the intersection of the Zodiac with the Equator. The position of a star on the celestial sphere is measured in the same way as the position of a point on the Earth's surface.

The name, astrolabe, has been given to a variety of instruments for measuring the positions of stars. Fig. I is based on a description by Ptolemy of an armillary astrolabe of the kind used in Alexandria between 150 B.C. and 150 A.D.

To an observer in the Northern hemisphere of the earth, the Pole Star appears to be fixed in the sky, at an angle of elevation equal to the latitude of the observer.

The other stars appear as if they are fixed on the inside of a huge dome, the celestial sphere, which rotates round the Pole Star 366¼ times a year. The sun appears to move slowly through the stars on a path called the ecliptic, or Zodiac Circle. It completes this circle once in a year, and therefore seems to revolve round the earth 365¼ times a year. The stars cannot be seen when the sun is up, but the sun's position on the ecliptic can be found by observations just before sunrise, and just after sunset.

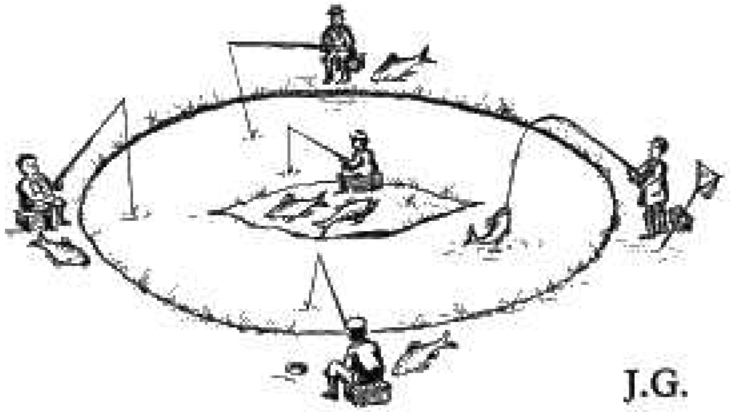
The armillary astrolabe was a model of the celestial sphere and ecliptic. (Armilla = bracelet). In Fig. I. the circular hoop, 1, is fixed vertically in a north-south plane. Inside it, is the circle, 2, which can be turned so that the line joining the two points, S and N, points to the Pole Star, and is then parallel to the axis of the earth. Circle 3 is pivoted at

17122 68066 13001 92787 66111 95909 21642 01989

CARTOON

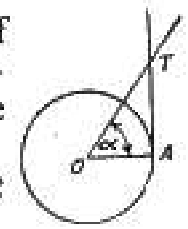
The angle at the centre is twice the angle at the circumference.

The Editor offers to present prizes for suggestions for more such cartoons.



J.G.

WHY WAS IT CALLED—No. 7



TANGENT: From Latin *tangent-(em)*, present participle of *tangere* (to touch). Imagine two radii of a circle, centre O, meeting at an angle α. The tangent touching the circle at A on the radius OA meets the other radius produced at some point T. The ratio of the tangent AT to the radius is called the *tangent* of the angle α.

COTANGENT: From *co-*, prefix (as above) and *tangent*, hence the tangent of the *complement* of an angle.

SECANT: = cutting: from Latin *secant-(em)*, present participle of *secare* (to cut). The ratio of the line OT mentioned under *tangent* to the radius is called the *secant* of the angle α because OT *cuts* the circumference and is, therefore, a *secant line*. The secant is easily seen to be the reciprocal of the cosine of α and, as such, is never less than unity.

COSECANT: From *co-* and *secant*: the secant of the complement of an angle. J.F.H.

SIMPLE ARITHMETIC

The sum of three numbers gives the same answer as their product. What are the numbers?

CHARLIE COOK NO. 8

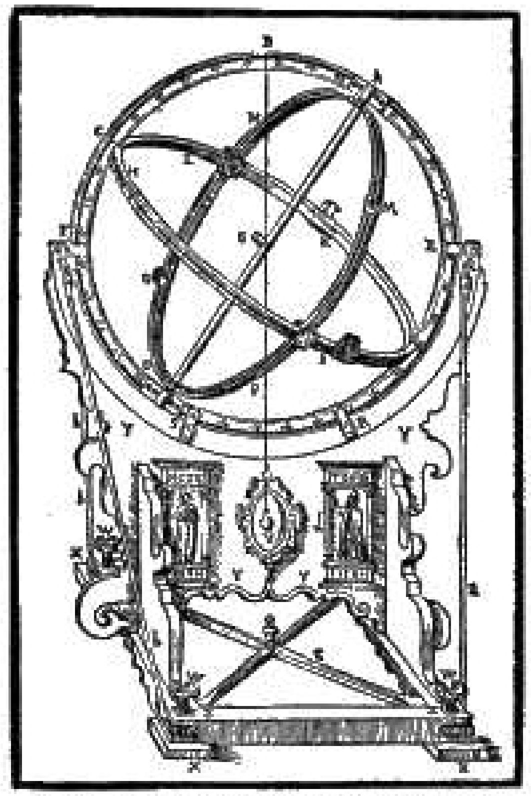
$$\frac{6+3\times 2}{2+2\times 3} = \frac{9\times 2}{4\times 3} = \frac{18}{12} = \frac{3}{2} \quad !!!$$

MARBLE(OUS) MATHEMATICS

Suggested by a problem in "Le Facteur X," No. 4, Jan. 1954.

Three boys were playing a marbles game in which the idea was to bowl a marble through a small hoop. If a player missed the hoop, he paid the other two players sufficient marbles to double their holding. The game went on till each boy had missed just once. On making a count, it was found that each boy now had 40 marbles. What numbers did they start with?

(Hint: no algebra necessary, just work backwards). J.F.H.



Tycho Brahe's ancillary equatorial 1580.
Crown Copyright, Science Museum, London.
Fig. 3.

N and S. Circle 4, which is fixed perpendicular to it, represents the ecliptic. This circle is marked with the signs of the Zodiac. The poles of the ecliptic are represented by the points P and Q, to which the circles 5 and 6 are pivoted.

Before making observations, the circles 3 and 4 had to be aligned with the celestial sphere. By night, this would be done by sighting on known stars. By day, circle 5 was turned so that the sun was in its plane, and then, by turning circle 3, the point of circle 4 representing the day of the year was brought up to it. Circle 7, which can turn inside circle 6, carries two sighting holes, A and B. When a star or planet was sighted with these, its position with respect to the fixed stars could be read off the scales on circles 4 and 6.

Although armillary astrolabes were difficult to make accurately, they continued in use for over 1000 years. Fig. 3 shows one made for the astronomer Tycho Brahe in 1580. Instead of measuring the position of stars with reference to the Zodiac Circle, as the Greeks did, Brahe used the Celestial Equator, thus making his instrument more simple. C.V.G.

ALPHA'S AQUA

Suggested by G. F. Plant, Form 5, Grammar School, Dartford, Kent.

At the Olympic Trials for mathematicians only, a circular race track of radius n yds. is used. *Alpha*, the best distance runner, always needs plenty of water to drink to keep him going. *Omega*, his trainer, has calculated that *Alpha* drinks t pints per yard. How much water will *Alpha* require for a race of s laps? [See Page 164.] I.H.

MARBLE PIE

A shopkeeper ordered 19 large and 3 small packets of marbles, all of the same sort. When these arrived at his shop, the box had been handled so roughly that all the packets had come open and the marbles were loose in the box. He counted 224 marbles, so how many should he put into a large packet and into a small packet respectively? (Hint: no algebra necessary). J.F.H.

S(H)OCKS

1. You wake up in a pitchblack room in a hunting lodge, and there's no light handy. In your duffel bag there are six black socks and six white ones, all mixed together. You want to pick out a matching pair. What is the smallest number of socks you can take out of the bag and be sure of getting a pair of the same colour?

FALLACY NO. 21

Problem : C and D are two points on a semi-circle, diameter AB, such that AD = DC and AC = CB. Find $\angle DCB$ given $\angle DAC = 25°$.

Method 1.

$\angle DCA = 25°$ ($\triangle DAC$ isosceles)

and $\angle ACB = 90°$ (angle in semi-circle)

$\therefore \angle DCB = \angle DCA + \angle ACB = \mathbf{115}°$

Method 2.

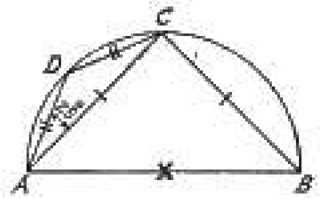
$\angle CAB = 45°$ ($\triangle ACB$ isosceles with $\angle ACB = 90°$)

but $\angle DAC = 25°$

$\therefore \angle DAB = \angle DAC + \angle CAB = 70°$

$\therefore \angle DCB = 180° - \angle DAB = \mathbf{110}°$

(opposite $\angle$'s of a cyclic quadrilateral)



Which is correct? I.H.

STAMP COLLECTORS CORNER—No. 2

Copernicus

German Occupation Forces 1 zloty. Rose. — Poland 20 Cr. Sepia. — Poland 80 Cr. Deep Blue.

Illustrated are three of the stamps issued in commemoration of the Polish astronomer Copernicus, who died in 1543. Before his time, it was believed that the Earth was the centre of the Universe, with Hell beneath and Heaven above the dome of the sky, which rotated above the Earth. In this theory, the motion of the planets was hard to explain. Copernicus put forward the theory that the Sun was a star and the Earth a planet, which like the five planets (the number then known), travelled in a circular orbit round the Sun. C.V.G.

SPOT THE SERIES

Find the next two numbers in each line :—

4	10	20	35	56	..	..
5	15	35	70	126	..	..
1	6	15	20	15	..	..
9	72	18	342	927	..	..
12	23	34	45	51	..	..
4	9	61	52	63	..	..

J.F.H.

49393 19255 06040 09277 01671 13900 98488 24012

HIGHWAY CODE

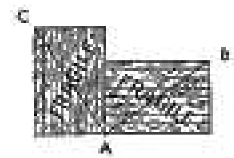
Contributed by Helen Wright, Form U VI, Fairfield High School, Manchester.

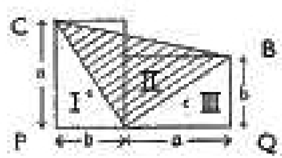
Given that M = J, what do the other letters represent?

```
      H A L T
          A T
  M A J O R
    R O A D
  ---------
  A H E A D
```

PYTHAGORAS AND PACKING CASES

It is surprising to find how quite common everyday objects can be used to suggest geometrical theorems. The diagram shows two equal packing cases with face diagonals. These diagonals are at right angles, for if the left-hand case were removed, the right-hand one could be rotated about the corner *A* through a right-angle, to occupy the left-hand position.

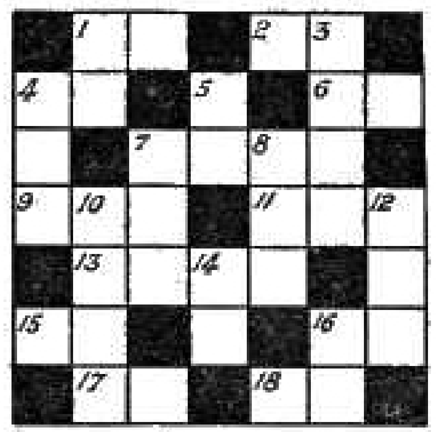




Suppose the dimensions of each packing case are *a* and *b*. Join *BC*. Then *PCBQ* is a trapezium, which is the sum of three right-angled triangles—I, II (shaded) and III.

Remembering the methods of finding the area of a trapezium and of a triangle, we can see that $\frac{(a+b)(a+b)}{2} = \frac{ab}{2} + \frac{c^2}{2} + \frac{ab}{2}$, which, on simplification, gives $a^2 + b^2 = c^2$, which is Pythagoras' Theorem. J.G.

SENIOR CROSS-FIGURE NO. 21



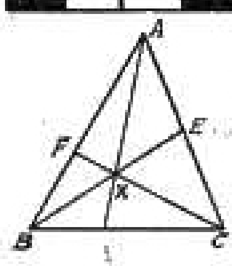


Figure 1

AB = 11 cm.
BC = 9 cm.
CA = 10 cm.

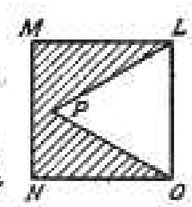


Figure 2

LMNO is a square LPO is an equilateral triangle

CLUES

ACROSS

1. Length BE when X is the centroid of triangle ABC. (See Fig. 1).
2. Distance, in miles, if by walking at 4 m.p.h. one-third of the way and cycling at 12 m.p.h. the remaining two-thirds of the way instead of walking two-thirds and cycling one-third saves 1 hr. 50 min.
4. The complement of the supplement of 101°.
6. Angle PLM. (See Fig. 2).
7. The reciprocal of $5\frac{1}{10}$.
9. $p^{\frac{1}{2}} + q^{\frac{1}{2}}$. (See 15 across and 1 down).
11. Cube root of ·3489.
13. Sum of the squares of $3\frac{1}{4} - 1\frac{1}{4}$ and $1\frac{1}{4} + 3\frac{1}{4}$.
15. q^2 where $p - q = 5$. (See 1 down).
16. The difference between the arithmetic and geometric means of 27 and 243.
17. Length LO if perimeter of LMNOP is 7 in. (See Fig. 2).
18. Length AF when X is the incentre of triangle ABC. (See Fig. 1).

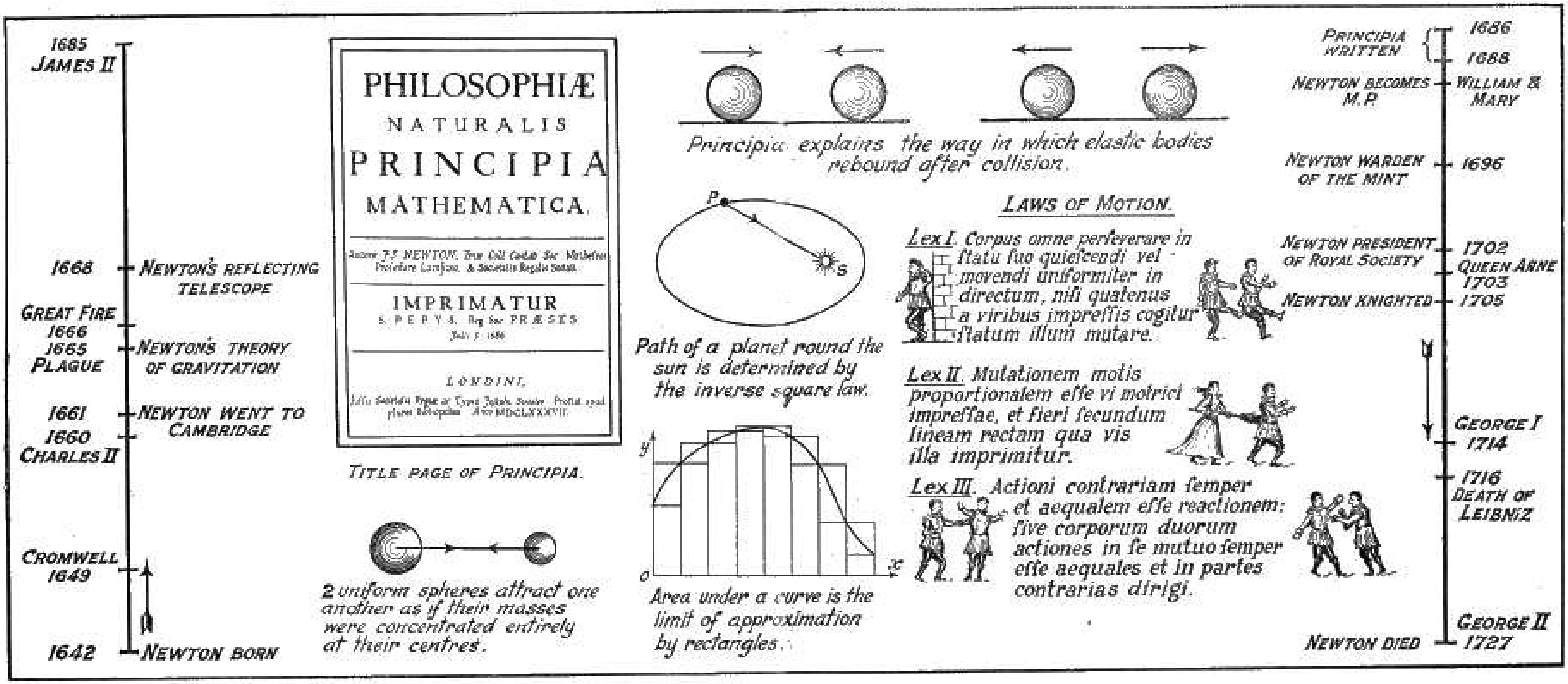
DOWN

1. p^2 where $\frac{2p+q}{p-2q} = 22$. (See 15 across).
3. Price paid for $5\frac{1}{4}$% stock at 110 to give an annual income of £122 after the deduction of income tax at 4s. 9d. in the pound.
4. Area shaded in Fig. 2. (See 17 across).
5. Angle ABC. (See Fig. 1).
7. A root of $2x^2 + 3x - 7 = 0$.
8. Area in square kilometres of a 217 acre park taking 1 m. = 39·37 in.
10. A perfect cube.
12. Area of triangle ABC. (See Fig. 1).
14. Angle BCF when X is the orthocentre of triangle ABC. (See Fig. 1).
16. Length AX when X is the circumcentre of triangle ABC. (See Fig. 1).

CHECK

The sum of the digits of the total sum of all the answers to the clues is 24. I.H.

82303 01952 03530 18529 68995 77362 25994 13891



Few centuries in our history have left so deep an impression as did the 17th century: a time of political and religious upheaval, the bubonic plague and the Great Fire. Yet it was during this century that Isaac Newton, the great mathematician, lived and studied.

Newton's education began at the Woolsthorpe village school and was continued at the Grammar School in Grantham. In 1661, he went up to Trinity College, Cambridge, and took his B.A. degree in 1664.

Much of Newton's early work was on the "theory of fluxions," now known as the calculus; and, later, he devoted his time to studying mechanics and investigating the laws which govern the motion of the planets.

For 20 years Newton worked on his theories, which he steadfastly refused to publish because he felt that they were incomplete. Finally, being persuaded by Sir Edmund Halley, he presented the "Principia" to the Royal Society and it was printed in 1687.

As was still the custom, the book was written in Latin; the full title being: "Philosophiae Naturalis Principia Mathematica" (The Mathematical Principles of Natural Philosophy).

The Principia consists of 3 books and is written with the clarity and methodical style of Euclid. It opens with a number of definitions, followed by the now famous laws of motion.

Law 1: Every body continues in its state of rest, or of uniform motion in a straight line, unless it is compelled to change that state by forces impressed upon it.

Law 2: The change of motion is proportional to the motive force impressed: and is made in the direction of the line in which that force is impressed.

Law 3: To every action there is always opposed an equal reaction.

Books I and II are both entitled "The Motion of Bodies," but the second book is devoted entirely to motion in a resisting medium, for example: the motion of some particle through a fluid. On looking through these books the reader cannot resist a feeling of profound amazement at Newton's methodical treatment of the subject of motion, which, with the help of a liberal supply of diagrams, leads one carefully from elementary ideas to the more complicated aspects of dynamics.

Book III, the "System of the World (in mathematical treatment)," is divided into five sections, in the last of which are detailed records of observations of Halley's comet, and the methods employed in calculating the path of this most famous of the comets.

The Principia is the greatest of all Newton's publications, and it has formed a firm basis for all subsequent work in dynamics and astronomy.

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24972 17752 83479 13151 55748 57242 45415 06959

50829 53311 68617 27855 88907 50983 81754 63746