1 Flanders Mathematics Olympiad 2000-2001: First Round.

The first round consists of 30 multiple choice problems which are selected by the FMO jury. Scores are computed as follows: a correct answer yields 5 points, a blanc answer 1 point and no points are given for a wrong answer. Participants may spend 3 hours solving the problems.

1.1 The problems

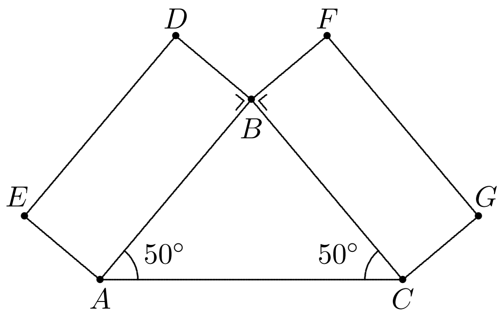
1. If the angles of a triangle are in the same ratio as the numbers 4, 5 and 6, then the largest angle measures

(A) $60°$	(B) $70°$	(C) $72°$	(D) $80°$	(E) $90°$

2. Let $n \in \mathbb{N}_0$. The number of integers that are less than n and greater than $-n$ equals

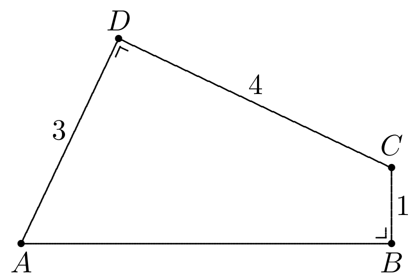
(A) $n-1$	(B) $2n-1$	(C) $2n$
(D) $2n+1$	(E) infinitely many	

3. Given an isosceles triangle ABC with base-angle of $50°$ and two quadrangles as shown in the picture.
Determine the angle $\widehat{DBF}$.



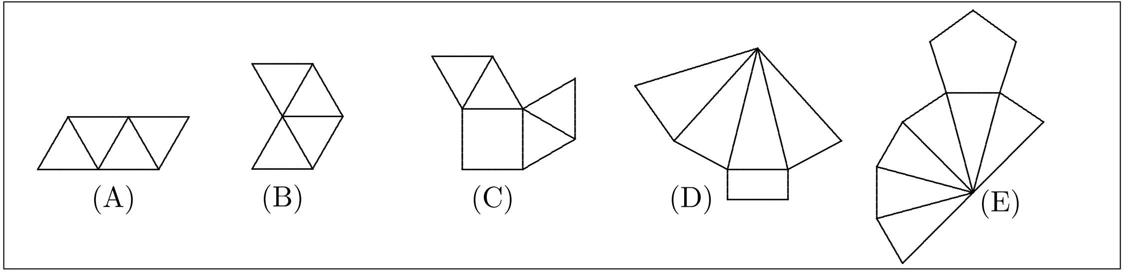
(A) $100°$	(B) $110°$	(C) $120°$	(D) $130°$	(E) $140°$

4. Given a quadrangle $ABCD$ with right angles in B and D. We also know that $|BC| = 1$, $|CD| = 4$ and $|DA| = 3$.
What is the area of $ABCD$?



(A) 8	(B) $6+\sqrt{6}$	(C) $8{,}5$	(D) 17	(E) $12+2\sqrt{6}$

5. Which one of the following figures is the development of a pyramid?



6. We want to cover (without overlaps) a rectangular panel of 24 cm by 105 cm with squares, that are not necessarily of the same size. How many squares are needed at least ?

(A) 9	(B) 10	(C) 24	(D) 168	(E) 2520

7. If $x : y = 6$, $y : z = 5$, $u : z = 4$ and $v : u = 3$, than $x : v =$

(A) 2,5	(B) 22,5	(C) 40
(D) 360	(E) none of the previous.	

8. Let a be a real number that satisfies $a^3 = a + 1$. Consider the following statements:
$a^4 = a^2 + a$ $\qquad a^4 = a^5 - 1$ $\qquad a^4 = a^3 + a^2 - 1$ $\qquad a^4 = \dfrac{1}{a-1}$
How many of them are correct?

(A) 0	(B) 1	(C) 2	(D) 3	(E) 4

9. Given the following sequence of fractions

$$\begin{array}{l} \frac{1}{1}, \\ \frac{1}{2}, \frac{2}{2}, \frac{1}{2}, \\ \frac{1}{3}, \frac{2}{3}, \frac{3}{3}, \frac{2}{3}, \frac{1}{3}, \\ \frac{1}{4}, \frac{2}{4}, \frac{3}{4}, \frac{4}{4}, \frac{3}{4}, \frac{2}{4}, \frac{1}{4}, \\ \ldots \end{array}$$

The nominator of the 2001th fraction is

(A) 24	(B) 25	(C) 26	(D) 27	(E) 28

10. A point P is on the hypothenuse of a rectangular triangle ABC with a right angle in A and having $[AB]$ as shortest edge. Let M be the foot of the perpendicular from P on AB and N the foot of the perpendicular from P on AC.
Where do we have to choose P so that the line segment $[MN]$ is the shortest possible?

(A) In B.
(B) In C.
(C) In the foot of the perpendicular from A on BC.
(D) In the intersection point of BC and the bissector of the right angle.
(E) In the midpoint of bisector $[BC]$.

11. Which one of the following volumes is the one of a can of coke ?

(A) 33 cm^3	(B) 330 cm^3	(C) 0,33 m^3	(D) 0,033 m^3	(E) 0,0033 m^3

12. It takes Sophie 30 seconds to reach the upper floor with a non-working escalator. A working escalator can bring someone (who doesn't move) to the upper floor in 60 seconds. How many seconds does Sophie need to reach the upper floor while walking on a working escalator?

(A) 15	(B) 20	(C) 25	(D) 45	(E) 90

13. Kamelixes have 3 times as much humps as dromedixes. A mixed herd of 24 of these animals has as much humps as 10 dromedixes and 6 kamelixes together.
How many dromedixes does the herd count?

(A) 14	(B) 16	(C) 18	(D) 20	(E) 22

14. On a meeting, every guest shakes hands, exactly once, with every other guest. There are 36 handshakes between 2 ladies and 28 between two gentlemen.
The number of handshakes between a gentleman and a lady is

(A) 17	(B) 36	(C) 72
(D) 136	(E) can not be determined.	

15. David obtained a set of 4 suitcases. The matching keys are in a little bag and are unmarked. The smallest number of attempts needed to find out which key matches which suitcase is

(A) 6	(B) 8	(C) 9	(D) 16	(E) 24

16. If $x^2 - x - 1$ is a divisor of $ax^3 + bx^2 + 1$, than b equals

(A) -2	(B) -1	(C) 0	(D) 1	(E) 2

17. We define the operation $*$ in $\mathbb{R}_0^+$ as follows:

$$a * b = \frac{1}{a+b}.$$

Which one of the following numbers is the smallest?

(A) $2*(3*1)$	(B) $2*(3*4)$	(C) $3*(1*2)$	(D) $3*(4*2)$	(E) $4*(2*3)$

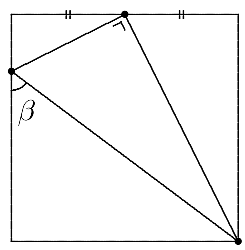
18. The minimum of the real function $f(x) = |x+3| + |x-2| + |x-4|$ equals

(A) 0	(B) 1	(C) 2	(D) 4	(E) 7

19. The number 14641 is the product of

(A) 2 prime numbers.	(B) 3 prime numbers.	(C) 4 prime numbers.
(D) 5 prime numbers.	(E) 6 prime numbers.	

20. A square is divided into rectangular triangles as shown in the figure.
The tangens of β equals



(A) 1	(B) $\frac{6}{5}$	(C) $\frac{5}{4}$	(D) $\frac{4}{3}$	(E) $\sqrt{2}$

21. From an enquiry of 100 advertisers in newspapers, it seems that

- 50 advertise in the Times (T)
- 52 advertise in the Daily Mirror (DM)
- 60 advertise in the Sun (S)
- 27 advertise in T and in S
- 26 advertise in T and in DM
- 30 advertise in S and in DM
- 14 advertise in these three newspapers.

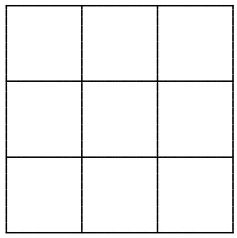
How many among those 100 advertisers place their advertisements exclusively in other newspapers?

(A) 0	(B) 2	(C) 4	(D) 7	(E) 12

22. In a box there are four kinds of marbles: 20 red ones, 12 yellow ones, 8 blue ones and 6 green ones. The smallest number of marbles one has to take out of the box to be sure that 10 marbles are of the same color equals

(A) 10	(B) 24	(C) 33	(D) 37	(E) 40

23. One can put a $\times$ in every square of the given lattice. If it is not allowed to put three $\times$ in a column, a row or a diagonal of the lattice, what is the maximum number of $\times$ that can be put into the lattice?



(A) 3	(B) 4	(C) 5	(D) 6	(E) 7

24. A square-shaped piece of metal with side a is bended to a cylindrical surface. The volume of the cylinder equals

(A) $\dfrac{a^3}{4\pi}$	(B) $\dfrac{a^3}{4}$	(C) $\dfrac{a^3}{\pi}$	(D) $\dfrac{\pi a^3}{4}$	(E) πa^3

25. Which one of the following expressions is the best approximation of $\sqrt{1-b}$ if $0 < b < 10^{-6}$?

(A) $1-b$	(B) $1-\dfrac{b}{2}$	(C) $1-b^2$	(D) $1-\dfrac{b^2}{2}$	(E) 1

26. In a TV-game three boys choose, independently, their favourite girl among three girls and at the same time, the three girls choose their favourite boy. If a boy and a girl choose each other, they win a trip. What is the probability that three trips are won (up to 0,1% accurate)?

(A) 0,2%	(B) 0,8%	(C) 2,5%	(D) 4,0%	(E) 16,7%

27. The sum of the first p terms of an arithmetic sequence equals q and the sum of the first q terms of that sequence is given by p $(p \neq q)$.
The difference v between two successive terms of that sequence is

(A) $v = \dfrac{-2}{p-q}$	(B) $v = -\dfrac{2(p+q)}{pq}$	(C) $v = \dfrac{2}{p+q}$
(D) $v = \dfrac{2(p-q)}{pq}$	(E) $v = 2(p+q)$	

28. Which one of the following numbers is the largest one? (Remind that $a^{b^c} = a^{(b^c)}$.)

(A) 333^3	(B) 33^{33}	(C) 3^{333}	(D) $3^{3^{33}}$	(E) $3^{3^{3^3}}$

29. If x is a prime number and $x^2 + y^2 = z^2$ where $x, y, z \in \mathbb{N}_0$, then $y =$

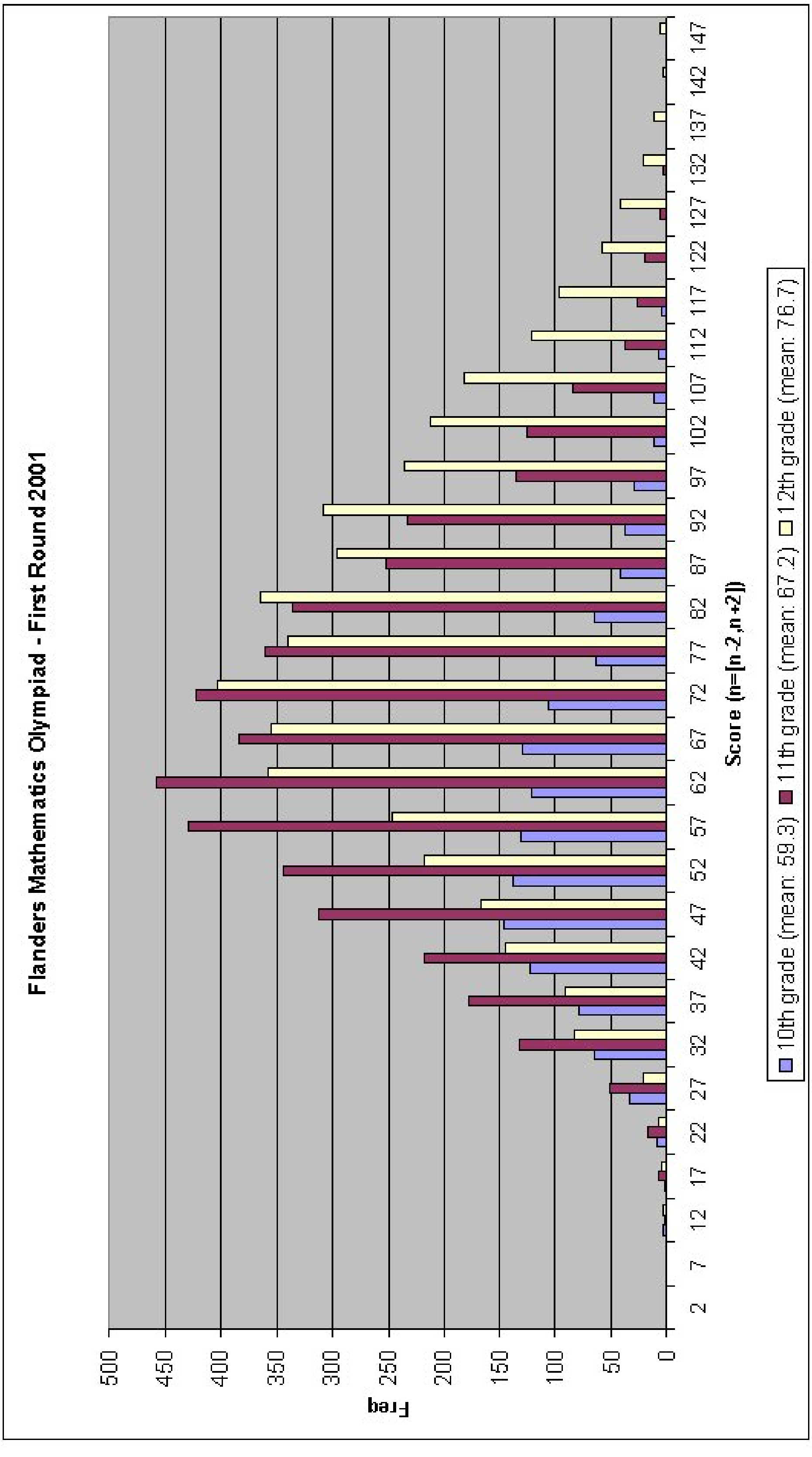
(A) $\dfrac{x^2-1}{2}$	(B) $\dfrac{x^2+1}{2}$	(C) x	(D) $x^2 - 1$	(E) $x^2 + 1$

30. A regular dodecagon has diagonals of five different lengths $d_1 < d_2 < d_3 < d_4 < d_5$.
The area of the regular dodecagon equals

(A) d_1^2	(B) d_2^2	(C) d_3^2	(D) d_4^2	(E) d_5^2

1.2 Answer Patterns of the First Round.

Flanders Mathematics Olympiad 2001 – First Round Answer Patterns (all participants)									
Problem	Correct	A	B	C	D	E	Correct	Wrong	Blank
1	C	1.51	16.55	67.49	5.36	3.05	67.49	26.48	6.04
2	B	13.04	56.35	3.61	1.93	15.29	56.35	33.90	9.75
3	A	93.32	1.41	1.79	0.64	0.28	93.32	4.16	2.52
4	B	1.80	67.47	7.59	1.38	6.03	67.47	16.79	15.74
5	A	37.20	15.34	9.60	20.89	11.06	37.20	56.97	5.83
6	A	53.05	10.48	5.67	3.72	6.51	53.05	26.41	20.54
7	A	65.58	2.31	2.54	3.60	8.82	65.58	17.27	17.15
8	E	6.37	32.81	13.30	7.89	8.52	8.52	60.38	31.10
9	B	6.42	17.56	5.03	5.30	3.49	17.56	20.24	62.20
10	C	14.86	2.81	45.52	16.32	7.41	45.52	41.42	13.06
11	B	12.33	67.86	4.63	4.58	5.85	67.86	27.42	4.72
12	B	29.47	48.79	3.63	4.10	0.54	48.79	37.77	13.44
13	E	2.23	4.63	8.99	1.99	59.07	59.07	17.85	23.08
14	C	2.11	4.90	47.43	6.84	9.97	47.43	23.84	28.73
15	A	27.99	5.91	45.05	6.61	5.42	27.99	63.01	9.00
16	A	17.58	9.58	6.23	7.69	3.12	17.58	26.63	55.79
17	E	4.45	13.04	6.34	2.73	52.43	52.43	26.59	20.98
18	E	8.81	6.17	18.81	2.01	41.47	41.47	35.84	22.69
19	C	9.08	9.31	24.24	4.34	1.36	24.24	24.09	51.67
20	D	5.54	2.67	5.93	29.23	6.69	29.23	20.83	49.93
21	D	5.79	3.70	5.04	26.83	3.17	26.83	17.71	55.46
22	C	1.93	10.54	60.33	8.76	2.87	60.33	24.10	15.56
23	D	2.00	7.03	32.59	56.84	0.17	56.84	41.81	1.36
24	A	43.43	3.34	3.83	14.17	8.41	43.43	29.78	26.78
25	B	8.17	10.21	8.52	6.10	20.62	10.21	43.41	46.38
26	B	14.69	13.61	6.84	6.94	8.99	13.61	37.48	48.90
27	B	1.86	5.78	2.48	5.54	1.88	5.78	11.77	82.46
28	D	2.40	11.54	26.04	31.23	7.39	31.23	47.39	21.38
29	A	26.80	4.19	3.40	3.76	2.30	26.80	13.65	59.55
30	C	2.42	2.53	26.20	7.41	9.82	26.20	22.18	51.62


Flanders Mathematics Olympiad - First Round 2001
Freq
0 50 100 150 200 250 300 350 400 450 500
2 7 12 17 22 27 32 37 42 47 52 57 62 67 72 77 82 87 92 97 102 107 112 117 122 127 132 137 142 147
Score (n=[n-2,n+2])
10th grade (mean: 59.3)
11th grade (mean: 67.2)
12th grade (mean: 76.7)

2 Flanders Mathematics Olympiad 2000-2001: Second Round.

The second round consists of 30 multiple choice problems which are selected bij the FMO jury. Scores are computed as follows: a correct answer yields 5 points, a blanc answer 1 point and no points are given for a wrong answer. Participants may spend 2 hours solving the problems.

2.1 The problems

1. Which number has to be added to the enumerator and the denominator of $\frac{1}{4}$, in order to obtain the fraction $\frac{n}{n+1}$?

(A) $1-n$	(B) $1-3n$	(C) $n-1$	(D) $n-3$	(E) $3n-1$

2. If the real numbers u, v, w satisfy $u < v < w < 0$, then which of the following propositions is incorrect?

(A) $vw < uw$	(B) $vu < wv$	(C) $u+w < v+w$
(D) $0 < w-u$	(E) $0 < uw$	

3. Consider $2^{\sqrt{2}}$, $\sqrt{2\ }^{2}$, $\sqrt{4^{\sqrt{2}}}$, $(\sqrt{2})^{\sqrt{8}}$, $\sqrt{8}$.
How many different numbers are given here?

(A) 1	(B) 2	(C) 3	(D) 4	(E) 5

4. The distance between two concentric circles (circles with the same midpoint) is 8 cm. A chord of the big circle is tangent to the small circle and measures 40 cm.
The radii of the circles measure (in cm)

(A) 21 and 18	(B) 23 and 15	(C) 25 and 17
(D) 27 and 19	(E) 29 and 21	

5. A tennis-tournament with $2n$ players is organised. n matches take place in the first round: each player competes just once with another player. In how many ways can the pairs of players be composed for the first round?

(A) n^2	(B) $n(2n-1)$
(C) $2n(2n-1)(2n-2)\ldots 3\cdot 2\cdot 1$	(D) $(2n-1)(2n-2)\ldots 3\cdot 2\cdot 1$
(E) $(2n-1)(2n-3)\ldots 3\cdot 1$	

6. A nurse needs 10 cc of a medicine that contains 15,5% of a certain substance A. To accomplish this, she mixes x cc of a solution containing 20% of A and y cc of a solution containing 5% of A. Then x

(A) $x \leq 6{,}5$	(B) $6{,}5 < x \leq 6{,}8$	(C) $6{,}8 < x \leq 7$
(D) $7 < x \leq 7{,}2$	(E) $7{,}2 < x$	

7. Two girls and a boy can pick one or more cakes. There are 8 different types of cakes, at least 4 of every kind. In how many ways can this be done if the boy picks 2 cakes and the girls each pick one?

(A) 2304 (B) 2048 (C) 840 (D) 512 (E) 420

8. Consider a rhombus with diagonals of length 6 and 8 and the inscribed circle C_1. The vertices of the rhombus are the midpoints of the sides of a rectangle, inscribed in a circle C_2. The ratio of the radius of C_1 and the radius of C_2 is

(A) less than 0,48 (B) 0,48 (C) 0,56
(D) 0,64 (E) greater than 0,64

9. The greatest common divisor of 878787878787 and 787878787878 equals

(A) 3 (B) 9 (C) 27
(D) 10101010101 (E) 30303030303

10. If $\sin x = 3\cos x$, then $\sin x \cos x$ equals

(A) $\frac{1}{6}$ (B) $\frac{1}{5}$ (C) $\frac{2}{9}$ (D) $\frac{1}{4}$ (E) $\frac{3}{10}$

11. For $a = 4$ it is known that the value of the fraction $\frac{(a+2)x + a^2 - 1}{ax - 2a + 18}$ is independent of x.

The other value or values of a for which this is the case, belong to the interval

(A) $]-\infty, -2[$ (B) $[-2, 0[$ (C) $[0, 2[$ (D) $[2, 4[$ (E) $[4, +\infty[$

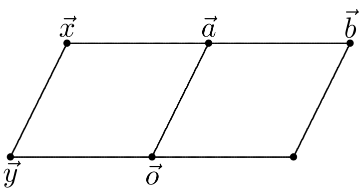
12. If $\sin\alpha + \cos\alpha = k$, then $|\sin\alpha - \cos\alpha|$ equals

(A) $\sqrt{2-k^2}$ (B) $\sqrt{k^2-2}$ (C) $|k|$ (D) $\sqrt{2}-k$ (E) $k-\sqrt{2}$

13. If a real function f satisfies $f(x) + x\,f(1-x) = x$ for every real value of x, then $f(2)$ equals

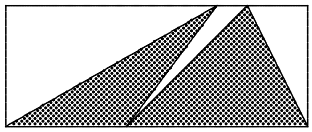
(A) $\frac{4}{3}$ (B) $\frac{5}{4}$ (C) $\frac{6}{5}$ (D) $\frac{7}{6}$ (E) $\frac{8}{7}$

14. In the picture, built up with two congruent parallelograms, $\vec{x} + \vec{y}$ equals



(A) $\vec{a} - 2\vec{b}$ (B) $-2\vec{b}$ (C) $3\vec{a} - 2\vec{b}$ (D) $-\vec{a} - 2\vec{b}$ (E) $-\vec{a} + 2\vec{b}$

15. The percentage of the shaded area in the rectangle equals



(A) 33	(B) 45	(C) 50	(D) 55	(E) 60

16. Consider, in an orthogonal coordinate system, the graphs of the functions
$f(x) = 1 + |x-2|$, $\quad g(x) = x^3 - 2$, $\quad h(x) = (x-2)^2 + 1$, $\quad k(x) = \dfrac{x}{1+x^2}$.
How many of those graphs have a vertical symmetry axis?

(A) 0	(B) 1	(C) 2	(D) 3	(E) 4

17. We define n-factorial and denote it by $n!$:

$$n! = n \cdot (n-1) \cdot \ldots \cdot 1 \text{ with } n \in \mathbb{N}_0$$

For example: $5! = 5 \cdot 4 \cdot 3 \cdot 2 \cdot 1 = 120$.
The number of values of n for which $1! + 2! + 3! + \ldots + n!$ is the square of a natural number equals

(A) 0	(B) 1	(C) 2	(D) 3	(E) more then 3

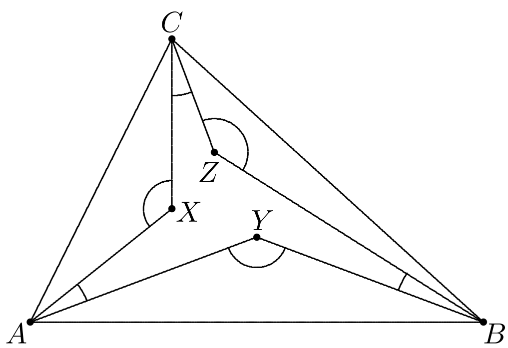
18. The quotient $\dfrac{6{,}8888\ldots}{2{,}4444\ldots}$ equals

(A) 3,2	(B) 3,2222...	(C) 3	(D) $\dfrac{17}{6}$	(E) $\dfrac{31}{11}$

19. What is the maximal greatest common divisor of 6 different natural numbers written with 2 digits?

(A) 13	(B) 15	(C) 16	(D) 18	(E) 23

20. We consider three points X, Y and Z in the inner part of a triangle ABC. We know that no pair of the line segments $[AX]$, $[AY]$, $[BY]$, $[BZ]$, $[CZ]$, $[CX]$ has more than one of the given points in common. We now obtain an irregular 3-pointed star. Determine the greatest lower bound and the smallest upper bound of the sum of the six angles $\hat{A}$, $\hat{B}$, $\hat{C}$, $\hat{X}$, $\hat{Y}$, $\hat{Z}$, marked in the figure.

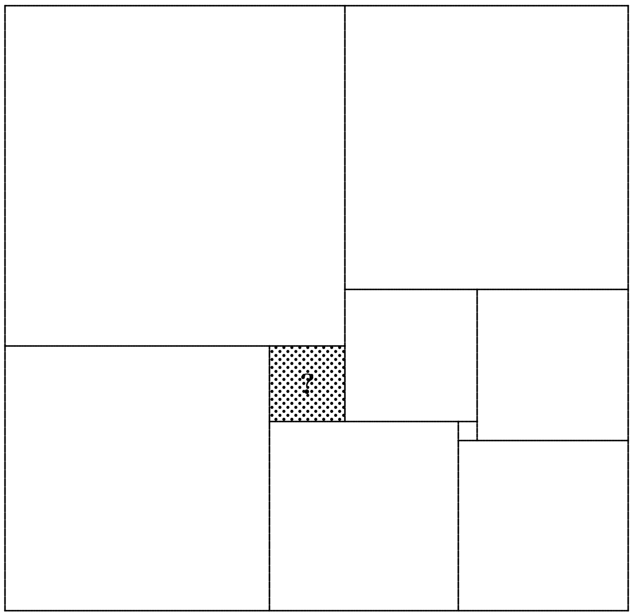


(A) $(2\pi, 4\pi)$	(B) $(2\pi, 5\pi)$	(C) $(3\pi, 4\pi)$
(D) $(3\pi, 5\pi)$	(E) We cannot determine them.	

21. Given a cube with edges of length a. The distance between an edge and an inner diagonal that has no point in common with the given edge, equals

(A) $\dfrac{a}{\sqrt{2}}$	(B) $\dfrac{a}{2}$	(C) $\dfrac{a}{\sqrt{3}}$	(D) $\dfrac{a\sqrt{2}}{\sqrt{3}}$	(E) $\dfrac{a}{2\sqrt{3}}$

22. Farmer George has divided his rectangle-shaped field in 9 squares as shown in the picture. The smallest square has an area of 1 m^2.
The area of the smallest but one square equals



(A) 9 m^2	(B) 12,25 m^2	(C) 16 m^2	(D) 20,25 m^2	(E) 25 m^2

23. Rosemary travels in a train counting 49 carriages, labeled in sequence from 1 to 49. She notices that the sum of the numbers less than the number of her carriage equals the sum of the numbers greater than the number of her carriage. Determine the number of the carriage Rosemary is travelling in.

(A) 31	(B) 32	(C) 33	(D) 34	(E) 35

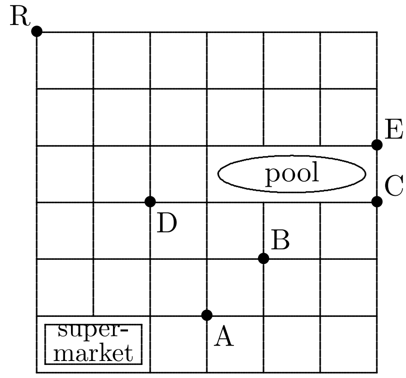
24. Mary and Ann play a game. One at a time they have to remove 1, 2 or 3 matches from a pile; the one taking the last match, loses the game. Ann has to begin, but Mary can choose the initial number of matches in the pile. Which number of matches in the pile guarantees Mary victory?

(A) 11	(B) 12	(C) 13	(D) 14	(E) 15

25. The last digit of $3^{2001} - 2^{2001}$ equals

(A) 1	(B) 3	(C) 5	(D) 7	(E) 9

26. Mohammed and René live in the same neighbourhood. Last summer, when Mohammed was travelling abroad for 8 weeks, René feeded the fishes of Mohammed. To do so, he could take a different shortest path from his house R to the house of Mohammed every day.
Mohammed lives in

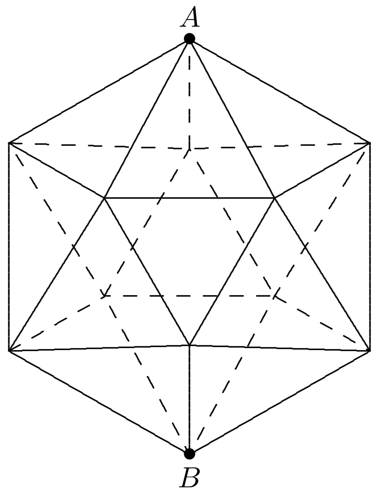


(A) A	(B) B	(C) C	(D) D	(E) E

27. A sharp-angled triangle with sides a,b and c with $a < b < c$ is rotated in space around each side, creating three different bodies of revolution. How do we create the body with the greatest volume?

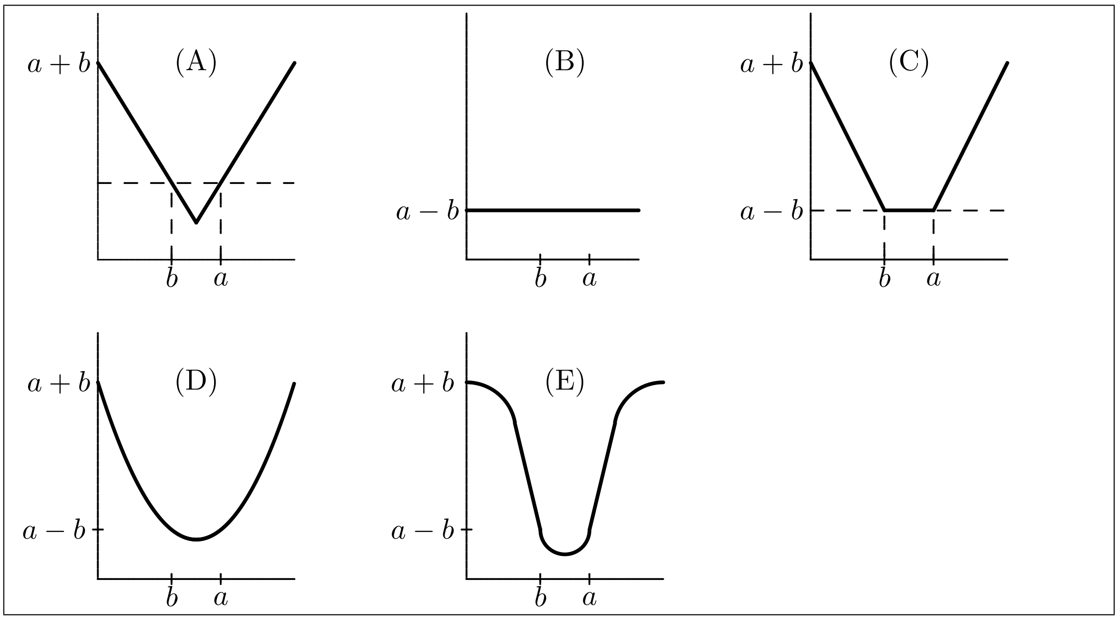
(A) By rotating around the side with length a.
(B) By rotating around the side with length b.
(C) By rotating around the side with length c.
(D) The three contents are equal.
(E) This problem cannot be solved.

28. Two aliens are situated on opposite vertices A and B of a planet shaped like a regular icosahedron, with edge 1 (as shown in the figure). The length of the shortest path from A to B along the surface of the planet equals



(A) $\sqrt{3}+1$	(B) $\sqrt{7}$	(C) 3	(D) $\frac{3\sqrt{2}}{2}$	(E) $\frac{3\sqrt{3}}{2}$

29. Consider three points O, A and B in the plane. Given is $a = |OA|$, $b = |OB|$ and $a > b$. Consider a circle with midpoint O and a variable radius r. The graph of the function that describes the relation between the sum of the distances from A and B to the given circle in function of the radius r of the circle, is given in



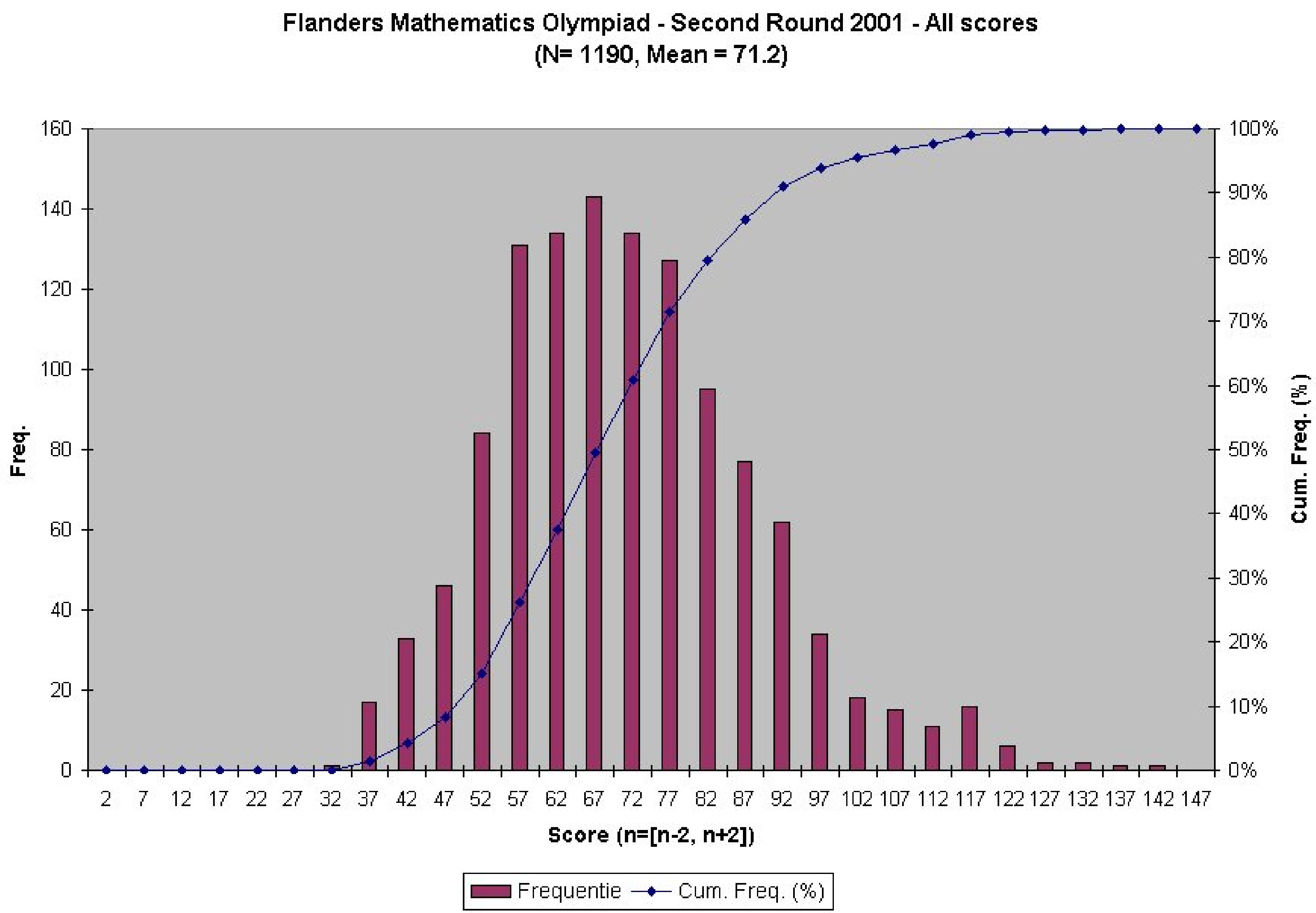
30. A first box contains 2 black and 2 green ballpoints. A second one contains 4 green and 6 red ballpoints. One randomly removes a ballpoint from the second box and places it in the first one. Then one randomly removes a ballpoint from the first box and places it in the second box. What is the probability that the boxes keep their original composition of colors ?

(A) 50%	(B) 36%	(C) 24%	(D) 18%	(E) 12%

2.2 Answer Patterns of the Second Round.

Flanders Mathematics Olympiad 2001 – Second Round
Answer Patterns (all participants)

Problem	Correct	A	B	C	D	E	Correct	Wrong	Blank
1	E	0.59	1.51	1.43	2.44	85.88	85.88	5.97	8.15
2	B	5.46	89.92	1.34	1.85	1.34	89.92	10.00	0.08
3	C	0.00	4.79	56.89	22.44	3.78	56.89	31.01	12.10
4	E	1.01	3.53	4.54	5.13	51.26	51.26	14.20	34.54
5	E	3.45	25.04	6.72	13.95	25.63	25.63	49.16	25.21
6	C	4.79	4.29	41.01	3.61	4.45	41.01	17.14	41.85
7	A	16.64	19.66	5.21	8.32	1.34	16.64	34.54	48.82
8	B	10.84	34.71	5.80	4.20	10.59	34.71	31.43	33.87
9	E	4.54	13.28	3.19	10.17	50.59	50.59	31.18	18.24
10	E	2.86	1.68	4.45	3.11	35.21	35.21	12.18	52.61
11	A	30.92	3.61	2.52	5.29	5.46	30.92	16.89	52.18
12	A	25.88	5.97	6.05	4.87	2.35	25.88	19.24	54.87
13	A	37.65	1.76	1.43	2.35	1.09	37.65	6.64	55.71
14	C	10.00	2.44	54.29	2.35	2.86	54.29	17.65	28.07
15	C	1.34	11.93	52.02	11.09	3.36	52.02	27.73	20.25
16	C	9.66	10.00	41.43	14.03	2.69	41.43	36.39	22.18
17	C	5.55	29.08	27.65	4.03	3.61	27.65	42.27	30.08
18	E	2.02	3.95	1.01	25.88	54.87	54.87	32.86	12.27
19	C	0.92	3.19	77.73	5.71	0.59	77.73	10.50	11.76
20	A	26.47	5.63	5.29	3.53	2.52	26.47	16.97	56.55
21	A	35.04	5.63	2.35	6.30	4.12	35.04	18.40	46.55
22	C	6.47	27.06	28.07	4.37	3.78	28.07	41.76	30.17
23	E	1.76	2.27	4.12	8.24	57.06	57.06	16.47	26.47
24	C	9.83	8.07	33.11	3.70	3.61	33.11	25.21	41.68
25	A	43.87	1.60	6.30	3.28	7.31	43.87	18.49	37.65
26	A	31.43	10.50	9.66	3.19	4.54	31.43	27.90	40.67
27	A	19.75	4.29	5.88	31.93	2.02	19.75	44.12	36.13
28	B	64.45	2.35	3.53	1.93	3.61	2.35	73.53	24.12
29	C	4.20	2.02	29.16	6.81	2.35	29.16	15.38	55.46
30	B	1.60	30.67	25.71	11.26	5.21	30.67	43.78	25.55


Flanders Mathematics Olympiad - Second Round 2001 - All scores
(N= 1190, Mean = 71.2)
Freq.
Cum. Freq. (%)
Score (n=[n-2, n+2])
Frequentie
Cum. Freq. (%)
0
20
40
60
80
100
120
140
160
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
2 7 12 17 22 27 32 37 42 47 52 57 62 67 72 77 82 87 92 97 102 107 112 117 122 127 132 137 142 147

3 The 2001 Final Round.

1. Prove that every natural number n greater than 1 satisfies:

$$(n-1)^2 \text{ is a divisor of } n^{n-1}-1.$$

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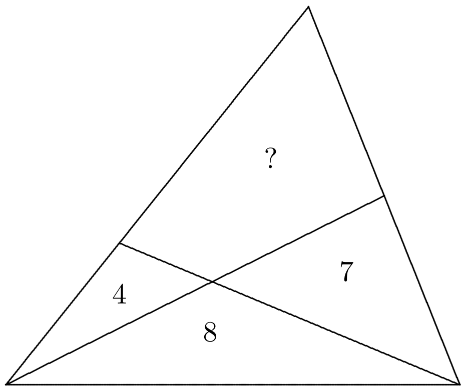
2. Two straight lines divide a triangle into four pieces. The area of three of those pieces is marked on the picture.
Determine the 4th area.



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3. A regular 2001-gon and a regular 667-gon are inscribed in a circle with radius 1 in a way that every vertex of the 667-gon is a vertex of the 2001-gon.
Prove that the area of the part of the 2001-gon that lies outside the 667-gon is given by the following expression:

$$k \sin^3 \frac{\pi}{2001} \cos^3 \frac{\pi}{2001} \text{ with } k \in \mathbb{N}$$

and determine k.

---

4. A student concentrates on solving quadratic equations in $\mathbb{R}$. He starts with a first quadratic equation $x^2 + ax + b = 0$ where a and b are both different from 0. If this first equation has solutions p and q with $p \leq q$, he forms a second quadratic equation $x^2 + px + q = 0$. If this second equation has solutions, he forms a third quadratic equation in an identical way. He continues this process as long as possible.
Prove that he will not obtain more than five equations.
