Math and Physics Contest "Phystech School 2020"

Problem Set 2 – recommended for grades 7 and 8

Math problems

1. (*2 points*) Grandfather collected 60 watermelons in the field. Then he shared the harvest with his neighbor and with his grandson. He gave his grandson 15 watermelons more than his neighbor. After that, he only had 29 watermelons left. How many watermelons did grandfather give to the neighbor?

2. (*3 points*) The flowerbed has more than 100, but less than 200 flowers. Of these, $\frac{7}{24}$ are roses, and $\frac{5}{18}$ are daisies. How many flowers does the flowerbed have?

3. The father told his youngest son Max that he would give him money if Max mastered social networks on his own next month while receiving excellent grades at school. The reward in common units equals:

$$a^2 + 2ab + b^2 - (c-d)(c-d) - (a+b+c-d)(a+b-c+d) + 10d,$$

where *a* is the number of new friends Max will have in social networks next month, *b* is a number of photos he will publish, *c* is a total number of "likes" under Max's posts, *d* is a total number of excellent grades Max gets in school. Max achieved the following result: *a* = 1119, *b* = 352, *c* = 651, *d* = 10.

1) *(2 points)* How much money in common units will Max get?

2) *(2 points)* On which of parameters *a*, *b*, *c* and *d* will the award depend?

4. *(4 points)* To lay a water pipe, they dug a trench, the cross section of which is an isosceles trapezoid (see figure). The width of the trench in the upper part is *l* = 10 m, in the lower part *d* = 4 m. The pipe laying depth is *h* = 3 m. Determine the angle *α* between the wall *S* and the bottom *d* of the trench.
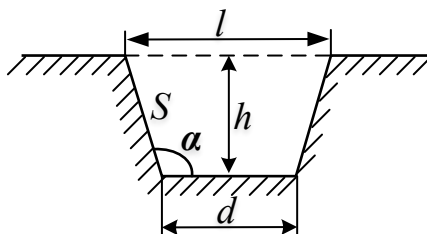
5. *(7 points)* Four girls competed among themselves in the contest "Miss Youth 2020". The contest consists of several stages. In each of them, the jury determined which of the participants would take the first, second, third and fourth places. At different stages, the girls received the same positive integer number of points for the same place. To determine the winner, the jury calculated the total number of points awarded for each girl separately over all stages. It turned out that the girls scored 16, 14, 13 and 12 points. How many stages did the contest consist of?

Physics problems

1. Postman Andy rides his bicycle to deliver mail. On March 21st, he went from the post office to the addressee. Having traveled 75% of the distance in 1 hour, Andy increased the speed to 25 km/h and it took him 1 more hour to reach the addressee, to turn back at once, and to return directly to the post office.

1) *(1 point)* Find the distance between the addressee and the post office.
2) *(1 point)* At what speed did Andy ride in the first hour?
3) Determine the displacement and total path length of Andy
       a) *(1 point)* over the first hour;
       b) *(1 point)* over the second hour;
       c) *(1 point)* over the whole trip.

ADDRESSEE

POST OFFICE

75%
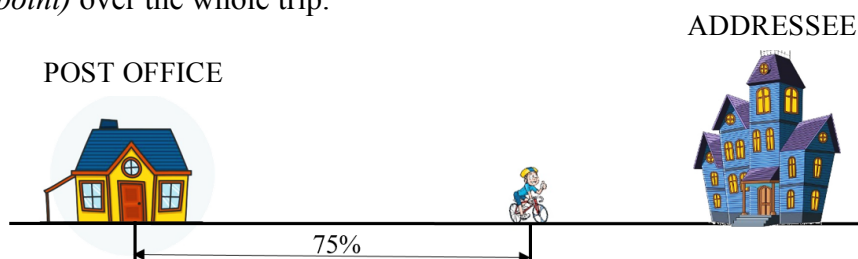
2. In a summer camp «Smarties», an inflatable pool was installed on an open sunny place. It is 5 m long, 3 m wide, and 1.5 m deep. In the morning, the camp staff filled the pool to the edges with well water, the temperature of which was 12 °C. From hot air and sunlight, the water warmed up to 17 °C towards the evening.

1) *(3 points)* How much heat did the pool water get?
2) *(3 points)* To what temperature would the water be heated if only a third of the pool was filled?

The specific heat capacity of water is $4,200 \frac{J}{kg \cdot °C}$, the water density is $1,000 \frac{kg}{m^3}$.

3. *(10 points)* A homogeneous rubber thread obeys Hooke's law. Some structure made of this thread is hidden in a closed tube, and only an inextensible thread attached to it comes out with a hook on its end. Pulling the hook to the right by a distance x from the end of the tube (see figure), we measured the force F necessary for this.

x

Measurement results were recorded in the following table:

x, cm	0	1	2	3	4	5	6	7	8	9	10	11	12
F, N	0	0	0	0.2	0.6	1.0	1.4	1.9	2.5	3.1	3.7	4.3	4.9

What could the rubber thread structure look like right before the start of measurements? Suggest at least one possible option. Unambiguously describe the geometric parameters and layout of this structure.

For example: «Immediately before the start of the experiment, the rubber thread could be folded into a circle with a radius of 1 cm, located in the plane of the figure. The left edge of the circle is attached to the left edge of the tube in the center, and the right edge is 5 cm from the right edge of the tube»[1].

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[1] This is the wrong answer to the problem. We cited it as an example of an unambiguous description of the geometric parameters of the structure and its location.