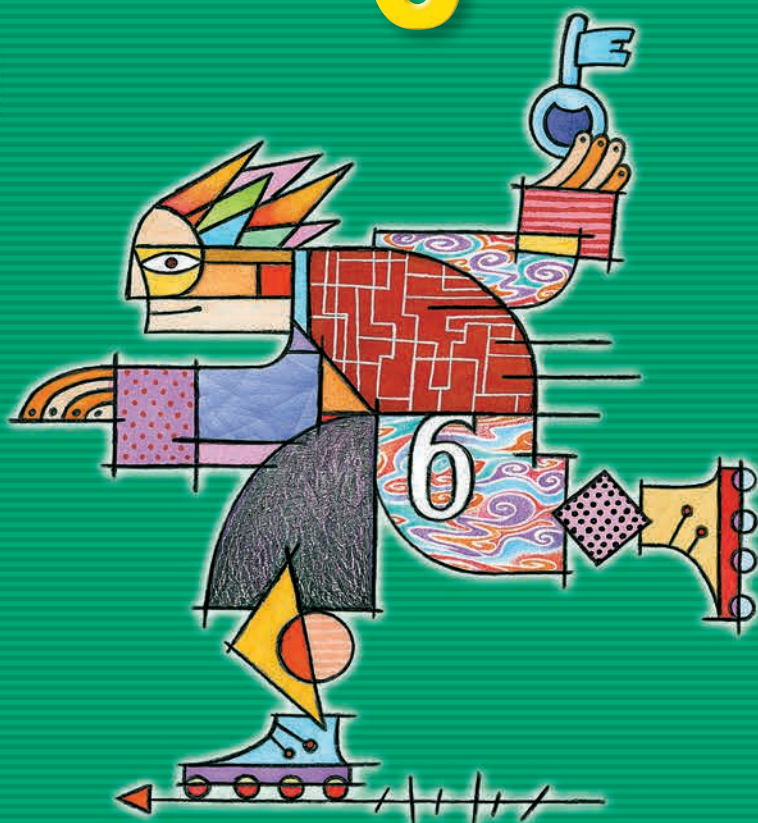


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colourful Mathematics

6





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Mathematics

textbook

6

Mozaik Education – Szeged, 2019

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Foreword and guide to this book.

It feels good to think. But do not assume, that only students who get good grades in math can feel this way. Everybody who can conquer a seemingly unsolvable problem through reason and logical thinking can experience this feeling.

You will encounter lots of practical problems this year. You will learn about the meaning of percentages, often mentioned in commercials; you will learn how to draw simple diagrams and construct geometric figures with a ruler and a compass. And most of all, you will improve your thinking skills while solving lots and lots of exercises.

The lessons usually start with sample problems. It is worth looking at, and understanding these, since they provide a template for solving further exercises. The most important rules and definitions are written in bold and highlighted in green. Exercises with a * may require clever solutions. The text on the side of the page in small print contains additional information, interesting facts about math, its uses in daily life or questions related to the given topic.

1

Divisibility





5. Divisibility Based on the Sum of the Digits



Frank arrived at the hall above in a computer game. To move on, he has to open one of the doors. Can he solve the problem in such a short time?

Example 1.

Use the number cards below to create numbers divisible by 9. How many solutions are there?

a) $\boxed{3} \quad \boxed{7} \quad \boxed{8}$

b) $\boxed{3} \quad \boxed{5} \quad \boxed{6}$

Solution (a)

$$\begin{aligned} 378 &= 42 \cdot 9 \\ 387 &= 43 \cdot 9 \\ 738 &= 82 \cdot 9 \\ 783 &= 87 \cdot 9 \\ 837 &= 93 \cdot 9 \\ 873 &= 97 \cdot 9 \end{aligned}$$

All of the numbers created with these number cards

$\boxed{3} \quad \boxed{7} \quad \boxed{8}$ are divisible by 9 .

Solution (b)

$$\begin{aligned} 356 &= 39 \cdot 9 + 5 \\ 365 &= 40 \cdot 9 + 5 \\ 536 &= 59 \cdot 9 + 5 \\ 563 &= 62 \cdot 9 + 5 \\ 635 &= 70 \cdot 9 + 5 \\ 653 &= 72 \cdot 9 + 5 \end{aligned}$$

None of the numbers create with these number cards

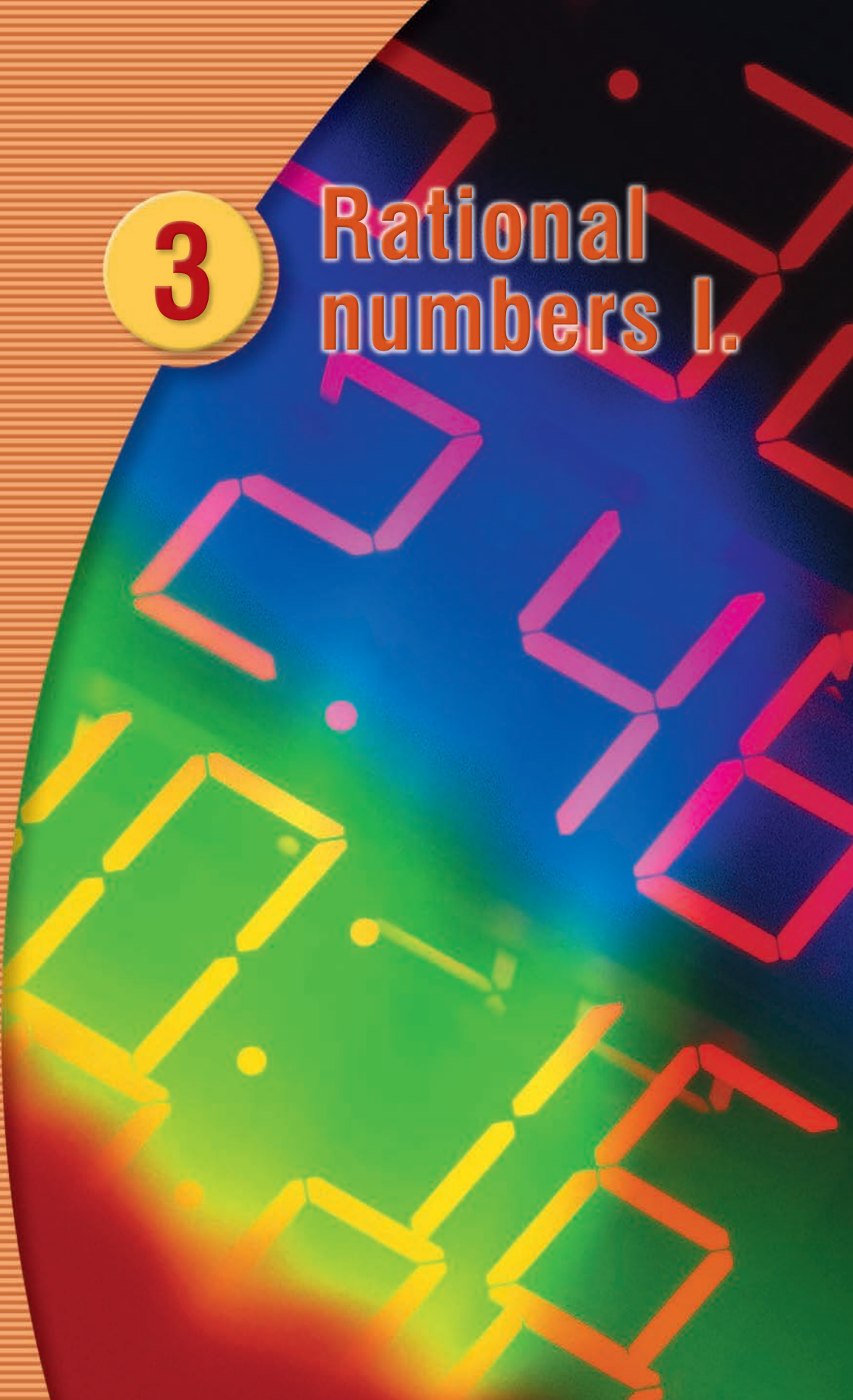
$\boxed{3} \quad \boxed{5} \quad \boxed{6}$ are divisible by 9.

Based on exercises a) and b) we can gather, that divisibility by 9 depends on the digits of a number, but not their order. In exercise a) the sum of the numbers is 18 (a multiple of 9), in exercise b) the sum of the numbers is 14 (not divisible by 9).

In the following examples we will show that the sum of the digits in a number indicates whether it is divisible by 9 or not.

3

Rational numbers I.





5. Dividing Integers



During a board game, Zoli stepped on the lucky field, so he could divide his 15 debt notes into three equal parts. How many notes did each child get? How did their position in the game change after this?

Example 1

Complete the following divisions.

a) $(-15) : (+3)$;

b) $(-15) : (-3)$.

Solution

a) $(-15) : (+3) = \diamond$.

Find the number, that when multiplied by $(+3)$ is (-15) , or

$$(+3) \cdot \diamond = -15.$$

This number is (-5) , because $(+3) \cdot (-5) = -15$.

Thus $(-15) : (+3) = -5$.

b) $(-15) : (-3) = \triangle$.

Find the number, that when multiplied by (-3) is (-15) , or

$$(-3) \cdot \triangle = -15.$$

This number is $(+5)$, because $(-3) \cdot (+5) = -15$.

Thus $(-15) : (-3) = +5$.

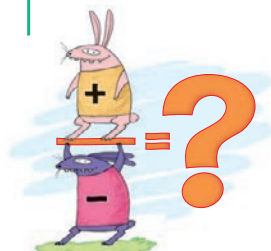
In the example we reverted the division of integers to the multiplication of integers.



Look at, how the sign of the quotient is related to the signs of the dividend and the divisor.

<p>$\cdot (+5)$ $(+4) \rightarrow (+20)$ $: (+5)$ $(+4) \leftarrow (+20)$</p>	$(+4) \cdot (+5) = (+20)$, thus $(+20) : (+5) = (+4)$.
<p>$\cdot (-5)$ $(+4) \rightarrow (-20)$ $: (-5)$ $(+4) \leftarrow (-20)$</p>	$(+4) \cdot (-5) = (-20)$, thus $(-20) : (-5) = (+4)$.
<p>$\cdot (+5)$ $(-4) \rightarrow (-20)$ $: (+5)$ $(-4) \leftarrow (-20)$</p>	$(-4) \cdot (+5) = (-20)$, thus $(-20) : (+5) = (-4)$.
<p>$\cdot (-5)$ $(-4) \rightarrow (+20)$ $: (-5)$ $(-4) \leftarrow (+20)$</p>	$(-4) \cdot (-5) = (+20)$, thus $(+20) : (-5) = (-4)$.

The quotient of two numbers with the same signs is a positive number, the quotient of two numbers with different signs is a negative number. To get the absolute value of the quotient, divide the absolute value of the dividend by the absolute value of the divisor.



Zero in the Division of Integers

If we divide 0 by an integer (other than zero) the quotient is zero.

$$0 : (-8) = 0, \text{ because } 0 \cdot (-8) = 0.$$

The divisor cannot be 0.

- $(-9) : 0 = \triangle$ would mean, that $\triangle \cdot 0 = -9$, but there is no such number, since multiplying any number by zero is zero.
- $0 : 0 = \square$ would mean, that $\square \cdot 0 = 0$, but multiplying any number by 0 is 0, thus we could write any number instead of \square . The quotient cannot be determined accurately, thus the $0 : 0$ quotient is undefined.

Dividing integers by 0 is undefined.

The dividend can be 0.

The divisor cannot be 0.



Exercises

1. Compare the quotients.

- a) $(+72) : (+6)$ $(+72) : (+3)$; b) $(+72) : (-6)$ $(+72) : (-3)$;
- c) $(-72) : (+6)$ $(+72) : (+3)$; d) $(-72) : (-6)$ $(+72) : (-3)$;
- e) $(-72) : (-6)$ $(-72) : (+3)$; f) $(-72) : (+6)$ $(-72) : (+3)$.

2. Put the quotients in increasing order.

3. Put the quotients in decreasing order.

- A: $(-108) : (+36)$; B: $(+72) : (-36)$; C: $(-108) : (-36)$;
- D: $(-108) : (-18)$; E: $(+108) : (+54)$; F: $(-54) : (-18)$.

4. Calculate the missing values, if $a \cdot b = -256$.

a	-8		-1	+64		+2		-16	
b		+16			-2		-32		+4

5. Fill in the missing numbers.

$$(-144) : \square = (+72) : \square = (-36) : (+3) = -12 : \square.$$

6. Determine which statement is true based on the quotient of $(-54) : (+18)$.

- a) If we multiply the dividend by -1 , the quotient changes -1 times.
- b) The quotient is unchanged if we divide the dividend and the divisor by $+2$.
- c) The quotient does not change if we add -6 to the dividend and the divisor.

7. What numbers can we divide

- a) -60 by, to integers greater than $+1$;
- b) $+36$ by to get integers less than -2 ;
- c) $+75$ to get integers divisible by 5 ?

8. How much should we subtract from the quotient of

- a) -51 and $+17$ to get -10 ;
- b) $+57$ and -3 to get $+10$;
- c) -81 and -9 to get -9 ?

9. a) How many times is the product of -12 and -24 of 18 ?

b) How many times is -2730 of the product of -13 and -14 ?

c) How many times is the product of 1716 and -13 , of 11 ?



10. How much did we multiply the quotient of
- a) -60 and $+10$ by, if we got an integer less than 10 ;
 - b) $+50$ and -10 if we got a two digit positive integer;
 - c) $+180$ and -45 if we got 0 ?
11. Which whole number is it?
- a) one fourth of -24 ;
 - b) four times -24 ;
 - c) -4 times -24 ;
 - d) we get -24 if we divide it by -4 ?
12. Choose a single digit positive integer. Write it down nine times to form a nine-digit integer. Divide this nine-digit number by -9 , then divide the resulting quotient with the opposite of the one-digit number you originally thought of. What do you notice? Repeat the process with other single digit numbers.
13. Add the sum of the digits to -999 , then divide the result by -9 . Is the resulting number divisible by 9 ?
14. Complete the divisions.
- a) $(+72) : [(+6) : (+3)]$;
 - b) $[(+16) : (+8)] : [(-2) : 0]$;
 - c) $[(-54) : (-9)] : [(-3) : (-1)]$;
 - d) $[(-49) : (-7)] : (+7)$;
 - e) $[(-54) : (-3)] : [(+6) : (-3)]$;
 - f) $0 : (+72) : (-9)$.
15. Divide 2520 by -7 , the result by -8 , then the resulting quotient by -9 . Divide 2520 by the product of -7 , -8 and -9 . Compare the two results.
16. The results of which divisions are equal?
- A) $(-39) : (-13)$;
 - B) $(+68) : (-20 + 3)$;
 - C) $(-3 - 57) : (-3 + 18)$;
 - D) $(-170) : (+10)$;
 - E) $(-63 - 37) : (+2)$;
 - F) $[-20 \cdot (-3 - 2)] : (-2)$;
 - G) $(-51) : (+3)$;
 - H) $(+135) : (+45)$;
 - I) $[-27 + (-9)] : (-12)$.
17. Which one is more? Pay attention to the order of operations.
- a) $(-100) : (-5) + (-5)$ or $(-100) : [-5 + (-5)]$;
 - b) $-24 - 80 : (-8)$ or $(-24 - 80) : (-8)$;
 - c) $+36 + (-60) : (-12)$ or $[+36 + (-60)] : (-12)$.
18. Draw a coordinate system. Draw a triangle with vertices, $A(+2; +12)$, $B(-8; -4)$ and $C(+4; 0)$. Use a different colour to draw the triangles generated from the original triangle by:
- a) multiplying the first coordinate of the vertices by -1 , the second is unchanged;
 - b) the first coordinates are unchanged, the second coordinates are divided by -2 ;
 - c) both coordinates are halved.

Q u i z

What is the smallest natural number divisible by every number from 1 to 10 ?

5

Rational numbers II.



6. Division by a Fraction



Example 1

How many people can share 3 pizzas, if we give each person

- a) 1; b) $\frac{1}{2}$; c) $\frac{1}{5}$ of a pizza?

Solution 1

We can see the number of resulting slices in the image above. We can get the same result by division:

- a) $3 : 1 = 3$; b) $3 : \frac{1}{2} = 6$; c) $3 : \frac{1}{5} = 15$.

Solution 2

Based on the properties of the quotient we know that if the dividend is unchanged and the divisor is reduced to half, or one fifth, then the quotient increases by two or by five times.

$$\begin{array}{ccc}
 \text{b) } 3 : 1 = 3 & & \text{c) } 3 : 1 = 3 \\
 \downarrow \cdot 2 & \downarrow \cdot 2 & \downarrow \cdot 5 & \downarrow \cdot 5 \\
 3 : \frac{1}{2} = 3 \cdot 2 & & 3 : \frac{1}{5} = 3 \cdot 5.
 \end{array}$$

We can give whole pizzas to 3, half pizzas to 6, and one fifth pizzas to 15 people.

$$3 : 6 = \frac{1}{2}$$

$$3 : \frac{1}{2} = 6$$

$$3 : 15 = \frac{1}{5}$$

$$3 : \frac{1}{5} = 15$$

the reciprocal
of $\frac{1}{2}$ is 2

Division by $\frac{1}{2}$ means multiplication by 2, division by $\frac{1}{5}$ means multiplication by 5.

Example 2

We poured four litres of peach juice into

- a) 1 litre bottle; b) $\frac{1}{3}$ litre glasses; c) $\frac{2}{3}$ litre pitchers.

How many bottles, glasses and pitchers are filled?





Solution

																bottles
																glasses
																pitchers

Based on the figure:

a) number of bottles: $4 : 1 = 4$.

b) number of glasses: $4 : \frac{1}{3} = 4 \cdot 3 = 12$.

c) number of pitchers: $4 : \frac{2}{3} = 6$.

Based on the changes of the quotient:

$$4 : 1 = 4$$

$$\downarrow :3 \quad \downarrow \cdot 3$$

$$4 : \frac{1}{3} = 4 \cdot 3$$

$$\downarrow \cdot 2 \quad \downarrow :2$$

$$4 : \frac{2}{3} = 4 \cdot \frac{3}{2}$$

Division by $\frac{2}{3}$ means multiplication by $\frac{3}{2}$. The reciprocal of $\frac{3}{2}$ is $\frac{2}{3}$.

Example 3

Complete the following divisions.

a) $3 : \frac{1}{5}$;

b) $3 : \frac{4}{5}$;

c) $\frac{3}{7} : \frac{4}{5}$.

Solution

a) In the first example, we saw, that $3 : \frac{1}{5} = 3 \cdot 5 = 15$.

b) We count based on the changes of the quotient.

$$3 : \frac{1}{5} = 3 \cdot 5$$

the divisor increases 4 times $\downarrow \cdot 4$ $\downarrow :4$ the quotient is reduced by one 4th

$$3 : \frac{4}{5} = (3 \cdot 5) : 4 = \frac{3 \cdot 5}{4} = 3 \cdot \frac{5}{4} = \frac{15}{4}$$

$$3 : \frac{4}{5} = 3 \cdot \frac{5}{4}$$

c) Counting by the changes of the quotient, take case b).

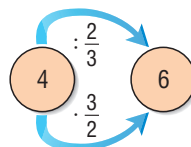
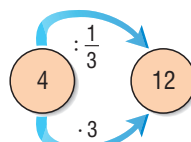
$$3 : \frac{4}{5} = 3 \cdot \frac{5}{4}$$

the dividend is reduced to one 7th $\downarrow :7$ $\downarrow :7$ the quotient is reduced by one 7th

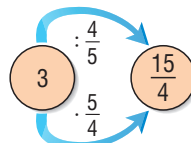
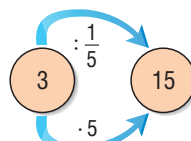
$$\frac{3}{7} : \frac{4}{5} = \frac{3}{7} \cdot \frac{5}{4} = \frac{15}{28}$$

$$\frac{3}{7} : \frac{4}{5} = \frac{3}{7} \cdot \frac{5}{4}$$

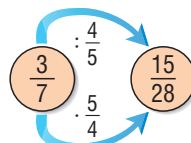
dividing a whole number



dividing a whole number



dividing by a fraction



We divide with fractions, by multiplying the dividend by the reciprocal of the divisor.

When dividing by a fraction we can simplify once we have written the division in the multiplication by the reciprocal form.

$$\frac{12}{5} : \frac{15}{4} = \frac{12}{5} \cdot \frac{4}{15} = \frac{\cancel{12}^4}{5} \cdot \frac{4}{\cancel{15}_5} = \frac{16}{25}$$

If there is a mixed number in the division, convert it to fraction form first.

$$2\frac{1}{4} : 1\frac{3}{5} = \frac{9}{4} : \frac{8}{5} = \frac{9}{4} \cdot \frac{5}{8} = \frac{45}{32} = 1\frac{13}{32}$$

If we divide numbers with signs, the signs of the numbers are determined the same way as with integers.

$$\frac{4}{5} : \left(-\frac{2}{3}\right) = \frac{4}{5} \cdot \left(-\frac{3}{2}\right) = -\left(\frac{\cancel{4}^2}{5} \cdot \frac{3}{\cancel{2}_1}\right) = -\frac{6}{5} = -1\frac{1}{5}$$

$$\left(-\frac{7}{8}\right) : \left(-\frac{3}{4}\right) = \left(-\frac{7}{8}\right) \cdot \left(-\frac{4}{3}\right) = \frac{7}{\cancel{8}_2} \cdot \frac{\cancel{4}^1}{3} = \frac{7}{6} = 1\frac{1}{6}$$



Exercises

1. Complete the following divisions, then check your answer.

a) $14 : \frac{7}{12}$; b) $14 : \frac{12}{7}$; c) $14 : 1\frac{5}{7}$; d) $\frac{28}{2} : \frac{7}{12}$;

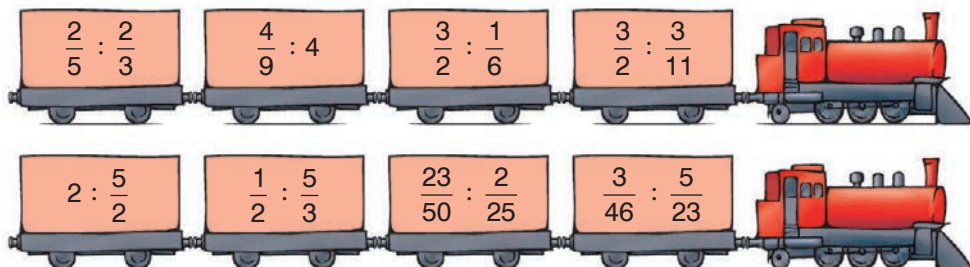
e) $(-5) : \frac{3}{4}$; f) $7 : \left(-\frac{2}{5}\right)$; g) $\left(-\frac{5}{7}\right) : \left(-\frac{5}{7}\right)$; h) $\frac{5}{13} : \frac{13}{5}$.

2. What is the quotient? Check your answer.

a) $\frac{5}{7} : 1\frac{2}{3}$; b) $\frac{6}{11} : 4\frac{2}{7}$; c) $\frac{30}{49} : 4\frac{2}{7}$; d) $\left(-\frac{7}{10}\right) : 2\frac{4}{5}$;

e) $4\frac{1}{4} : 8\frac{1}{2}$; f) $\left(-9\frac{1}{2}\right) : \left(-2\frac{1}{9}\right)$; g) $\left(-7\frac{4}{5}\right) : 1\frac{3}{10}$; h) $5\frac{1}{8} : \left(-8\frac{1}{5}\right)$.

3. What number is the entire train carrying?





4. What numbers can we write in place of the symbols to make the equations true?

a) $\frac{2}{3} : \Delta = \frac{4}{3}$; b) $\left(-\frac{3}{5}\right) : \Delta = \frac{9}{10}$; c) $\frac{5}{8} : \Delta = \frac{3}{14}$;
 d) $\left(-1\frac{4}{5}\right) : \Delta = \frac{5}{6}$; e) $\frac{3}{4} : \Delta = 2\frac{1}{2}$; f) $\frac{21}{25} : \Delta = 2\frac{9}{20}$.

5. a) What is the quotient if we divide $\left(-6\frac{1}{4}\right)$ by $4\frac{1}{6}$?

b) How many times $4\frac{1}{6}$ is $\left(-6\frac{1}{4}\right)$?

c) How many times $\left(-6\frac{1}{4}\right)$ is $4\frac{1}{6}$?

d) What do we have to multiply $4\frac{1}{6}$ by to get $\left(-6\frac{1}{4}\right)$?

6. Complete the divisions. Which is greater? The dividend or the quotient?

a) $\frac{2}{3} : \frac{4}{5}$; $\frac{7}{8} : \frac{1}{2}$; $\frac{2}{9} : \frac{2}{3}$. b) $\frac{2}{3} : \frac{3}{2}$; $1\frac{1}{3} : \frac{4}{3}$; $\frac{9}{4} : \frac{5}{4}$.

7. The area of a rectangle is $25\frac{1}{2} \text{ m}^2$. What is its perimeter if one side is $8\frac{1}{2} \text{ m}$ long?

8. Write down as many divisions as possible so that both the dividend the divisor as well as the quotient are among the following numbers.

$\frac{9}{8}$; -4 ; $\frac{5}{2}$; 4 ; $\frac{6}{5}$; $-\frac{5}{8}$; $\frac{3}{2}$.

9. Vince and Carl have been cycling for an hour and a half, when they completed $\frac{3}{4}$ of their trip. What portion of their trip did they complete in 1 hour? How much time is left until the end of the trip, if they continue at the same pace?



Quiz

We multiply a number by $\frac{3}{4}$, then divide it by $\frac{3}{5}$. Which of the following operations are equivalent to these two operations?

A) division by $\frac{4}{3}$; B) division by $\frac{9}{20}$; C) multiplying by $\frac{9}{20}$; D) multiplying by $\frac{5}{4}$; E) division by $\frac{5}{4}$.

7

Percentages



6. Calculating the Percent



MEN'S HANDBALL CHAMPIONSHIP
SZEGED - VESZPRÉM 28 - 25

STATISTICS:

GOALS / SHOTS

28/47 (59.6%) 25/54 (46.3%)

7 M SHOTS

3/4 (75%) 2/3 (66.7%)

BLOCKS / SHOTS

13/38 (34.2%) 10/38 (26.3%)



Example 1

In the 25th minute of the Szeged–Veszprém handball match, Szeged was leading 15 : 12. The 15 goals resulted from 20 shots. What percent of the shots were goals?

Solution 1

20 shots	100%
15 shots	?
$\frac{20}{100}$ shots	1%

$$15 \text{ shots} \qquad 15 : \frac{20}{100} \% = 15 \cdot \frac{100}{20} \% = 75\%$$

Solution 2

20 shots	100%
1 shots	$\frac{100}{20} \% = 5\%$
15 shots	$15 \cdot 5\% = 75\%$

Solution 3

1 shot is $\frac{1}{20}$ of 20 shots,

15 shots is $\frac{15}{20}$ of 20.

$$\frac{15}{20} = \frac{75}{100} \rightarrow 75\%.$$

The Szeged handball team realized a goal from 75% of the shots until the 25th minute of the game.



Example 2

There were 30 athletes at school last year. This year, there are 42. What is the percent of athletes this year, compared to last year?

Solution 1

Take last year's number to be 100%

30 students	100%
42 students	?
1 student	$\frac{100}{30}\%$
42 students	$\cancel{42} \cdot \frac{100}{\cancel{30}}\% = \frac{700}{5}\% = 140\%$

Solution 2

42 students is $\frac{42}{30}$ times 30 students.

$$\frac{42}{30} = \frac{7}{5} = 1.4. \quad 1.4 \text{ parts is } = 140\%.$$

The number of athletes this year, is 140% of those last year.

The number of athletes increased by 40%

Example 3

In one store there is a 25% discount on a juice and at an other store there is a “buy two, get one free” sale for the same juice. Where should you buy the juice?

Solution

At one store, the discount is 25%.

At the other store we get three juices for the price of two.

3 boxes of juice	100%
1 box of juice	$\frac{100}{3}\%$
2 boxes of juice	$2 \cdot \frac{100}{3}\% = 66.\dot{6}\% \approx 66.7\%$

Thus the discount is $100\% - 66.7\% = 33\%$.

Solution 2

If we buy 3 boxes of juice for the price of 2, then we buy one box at $\frac{2}{3}$ price.

$$\frac{2}{3} = 0.666 \approx 0.667. \quad 0.667 \text{ part} = 66.7\%. \quad \text{The discount is } 33.3\%.$$

It is better to buy the juice at the “buy two, get one free” sale.



14. A family spends 50 000 Ft of its 180 000 Ft monthly income on bills (gas, electricity, water, telephone, internet, newspaper), 85 000 Ft on food and household items, 28 000 Ft on commuting and the rest on other expenses. What percent of its income does the family spend on other expenses?
15. Ask your parents, what percent of your family income you spend on bills and food. What percent is spent on entertainment?
16. The table shows the number of students who entered the math competition.

grade	3.	4.	5.	6.	7.	8.
number of students	12	24	27	33	15	9

What % of the students were in third, fourth, fifth, ..., grade?

17. What percent discount did the sports store reduce the price of the items by?



Quiz

Crisis in the New Village sports club!

The local newspaper tried to find out what caused the poor performance of the local NVS soccer team.

– I feel the charges against me are unfounded. Our performance in the spring season increased by 100%! – the coach replied.

– The NVS has never performed this poorly! They only won 3 of their 30 games – said the representative of the fan's association.

They both told the truth. How is this possible?