New Jersey Center for Teaching and Learning

Progressive Mathematics Initiative

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Scientific Notation

8th Grade

2012-09-24

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Purpose of Scientific Notation

Scientists are often confronted with numbers that look like this:

300,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,00(
000 kg

Can you guess what weighs this much?

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Can you match these BIG objects to their masses?

300,000,000,000 kg

**2,000,000,000,000,000,
000,000,000,000,000 kg**

600,000,000 kg

**60,000,000,000,000,
000,000,000,000 kg**

180,000 kg

Can you match these BIG objects to their masses?

Click object to reveal answer

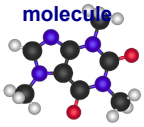
Can you match these small objects to their masses?

0.00015 kg

grain of sand

0.000000000000000000000000030 kg

molecule



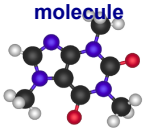
0.00000000035 kg

steam

Click to reveal answers.

grain of sand

molecule



steam

Scientific Notation

The examples were written in "standard form", the form we normally use. But the standard form is difficult when a number is HUGE or tiny, if it has a lot of zeros.

Scientists have come up with a more convenient method to write very LARGE and very small numbers.

Writing numbers in scientific notation doesn't change the value of the number.

Scientific Notation

Scientific Notation uses Powers of 10 to write big or small numbers more conveniently.

Using scientific notation requires us to use the rules of exponents we learned earlier. While we developed those rules for all bases, scientific notation only uses base 10.

Powers of Ten

$10^1 = 10$
$10^2 = 10 \times 10 = 100$
$10^3 = 10 \times 10 \times 10 = 1{,}000$
$10^4 = 10 \times 10 \times 10 \times 10 = 10{,}000$
$10^5 = 10 \times 10 \times 10 \times 10 \times 10 = 100{,}000$

click here to see a video on powers of ten which puts our universe into perspective!

Powers of Integers

Powers are a quick way to write repeated multiplication, just as multiplication was a quick way to write repeated addition.

These are all equivalent:

10^3
$(10)(10)(10)$
1000

In this case, the base is 10 and the exponent is 3.

Exponent Rules

Remember that when multiplying numbers with exponents, if the bases are the same, you write the base and add the exponents.

$2^5 \times 2^6 = 2^{(5+6)} = 2^{11}$

$3^3 \times 3^7 = 3^{(3+7)} = 3^{10}$

$10^8 \times 10^3 = 10^{(8+-3)} = 10^5$

$4^7 \times 4^7 = 4^{(7+-7)} = 4^0 = 1$

1 $10^2 \times 10^4 =$

- A 10^6
- B 10^8
- C 10^{10}
- D 10^{12}

2 $10^{14} \times 10^{-6} =$

- A 10^6
- B 10^8
- C 10^{10}
- D 10^{12}

3 $10^{-4} \times 10^{-6} =$

- A 10^{-6}
- B 10^{-8}
- C 10^{-10}
- D 10^{-12}

4 $10^{4} \times 10^{6} =$

- A 10^{6}
- B 10^{8}
- C 10^{10}
- D 10^{12}

Writing Numbers in Scientific Notation

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Writing Large Numbers in Scientific Notation

Scientific Notation

Here are some different ways of writing 6,500.

6,500 = 6.5 thousand
6.5 thousand = 6.5 x 1,000
6.5 x 1,000 = 6.5 x 10^{3}

which means that 6,500 = 6.5 x 10^{3}

6,500 is standard form of the number and 6.5 x 10^{3} is scientific notation

These are two ways of writing the same number.

Scientific Notation

6.5 x 10^{3} isn't a lot more convenient than 6,500.

But let's do the same thing with 7,400,000,000
which is equal to 7.4 billion
which is 7.4 x 1,000,000,000
which is 7.4 x 10^{9}

Besides being shorter than 7,400,000,000, its a lot easier to keep track of the zeros in scientific notation.

And we'll see that the math gets a lot easier as well.

Scientific Notation

Scientific notation expresses numbers as the product of:

a coefficient and 10 raised to some power

3.78×10^6

The coefficient is always greater than or equal to one, and less than 1

In this case, the number 3,780,000 is expressed in scientific notation.

Express 870,000 in scientific notation

1. Write the number without the comma. **870000**
2. Place the decimal so that the first number will be less than 10 but greater than or equal to 1. **870000 x 10**
3. Count how many places you had to move the decimal point. This becomes the exponent of 10. **870000 x 10** (5 4 3 2 1)
4. Drop the zeros to the right of the right-most non-zero digit. **8.7×10^5**

Express 53,600 in scientific notation

1. Write the number without the comma. _____
2. Place the decimal so that the first number will be less than 10 but greater than or equal to 1. _____
3. Count how many places you had to move the decimal point. This becomes the exponent of 10. _____
4. Drop the zeros to the right of the right-most non-zero digit. _____

Express 284,000,000 in scientific notation

1. Write the number without the comma. _____

2. Place the decimal so that the first number will be less than 10 but greater than or equal to 1. _____

3. Count how many places you had to move the decimal point. This becomes the exponent of 10. _____

4. Drop the zeros to the right of the right-most non-zero digit. _____

5 Which is the correct coefficient of 147,000 when it is written in scientific notation?

- A 147
- B 14.7
- C 1.47
- D .147

6 Which is the correct coefficient of 23,400,000 when it is written in scientific notation?

- A .234
- B 2.34
- C 234.
- D 23.4

7 How many places do you need to move the decimal point to change 190,000 to 1.9?

- A 3
- B 4
- C 5
- D 6

8 How many places do you need to move the decimal point to change 765,200,000,000 to 7.652?

- A 11
- B 10
- C 9
- D 8

9 Which of the following is 345,000,000 in scientific notation?

- A 3.45×10^8
- B 3.45×10^6
- C 345×10^6
- D $.345 \times 10^9$

10 Which of these is <u>not</u> a number greater than one in scientific notation?

- ❑ A $.34 \times 10^{8}$
- ❑ B 7.2×10^{3}
- ❑ C 8.9×10^{4}
- ❑ D 2.2×10^{-1}
- ❑ E 11.4×10^{12}
- ❑ F $.41 \times 10^{3}$

The mass of the solar system

300,000,000,000,000,
000,000,000,000,000,
000,000,000,000,000,
000,000,000 kg

(How do you even say that number?)

More Practice

Express 9,040,000,000 in scientific notation

1. Write the number without the comma. _____

2. Place the decimal so that the first number will be less than 10 but greater than or equal to 1. _____

3. Count how many places you had to move the decimal point. This becomes the exponent of 10. _____

4. Drop the zeros to the right of the right-most non-zero digit. _____

Express 13,030,000 in scientific notation

1. Write the number without the comma. _____

2. Place the decimal so that the first number will be less than 10 but greater than or equal to 1. _____

3. Count how many places you had to move the decimal point. This becomes the exponent of 10. _____

4. Drop the zeros to the right of the right-most non-zero digit. _____

Express 1,000,000,000 in scientific notation

1. Write the number without the comma. _____

2. Place the decimal so that the first number will be less than 10 but greater than or equal to 1. _____

3. Count how many places you had to move the decimal point. This becomes the exponent of 10. _____

4. Drop the zeros to the right of the right-most non-zero digit. _____

11 **Which of the following is 12,300,000 in scientific notation?**

- A $.123 \times 10^8$
- B 1.23×10^5
- C 123×10^5
- D 1.23×10^7

Writing Small Numbers in Scientific Notation

Express 0.0043 in scientific notation

1. Write the number without the decimal point. 0043
2. Place the decimal so that the first number is 1 or more, but less than 10. $0043 \times 10^{?}$
3. Count how many places you had to move the decimal point. The negative of this numbers becomes the exponent of 10. $0043 \times 10^{?}$ (1 2 3)
4. Drop the zeros to the left of the left-most non-zero digit. 4.3×10^{-3}

Express 0.00000832 in scientific notation

1. Write the number without the decimal point. _____

2. Place the decimal so that the first number is 1 or more, but less than 10. _____

3. Count how many places you had to move the decimal point. The negative of this numbers becomes the exponent of 10. _____

4. Drop the zeros to the left of the left-most non-zero digit. _____

Express 0.0073 in scientific notation

1. Write the number without the decimal point. _____

2. Place the decimal so that the first number is 1 or more, but less than 10. _____

3. Count how many places you had to move the decimal point. The negative of this numbers becomes the exponent of 10. _____

4. Drop the zeros to the left of the left-most non-zero digit. _____

12 Which is the correct decimal placement to convert 0.000832 to scientific notation?

- **A 832**
- **B 83.2**
- **C .832**
- **D 8.32**

13 Which is the correct decimal placement to convert 0.000000376 to scientific notation?

- A 3.76
- B 0.376
- C 376.
- D 37.6

14 How many times do you need to move the decimal point to change 0.00658 to 6.58?

- A 2
- B 3
- C 4
- D 5

15 How many times do you need to move the decimal point to change 0.000003242 to 3.242?

- A 5
- B 6
- C 7
- D 8

16 Write 0.00278 in scientific notation.

- A 27.8×10^{-4}
- B 2.78×10^{3}
- C 2.78×10^{-3}
- D 278×10^{-3}

17 Which of these is the only number larger than 1 in scientific notation?

- A $.34 \times 10^{-8}$
- B 7.2×10^{-3}
- C 8.9×10^{4}
- D 2.2×10^{-1}
- E 11.4×10^{-12}
- F $.41 \times 10^{-3}$

More Practice

Express 0.001003 in scientific notation

1. Write the number without the decimal point. _____

2. Place the decimal so that the first number is 1 or more, but less than 10. _____

3. Count how many places you had to move the decimal point. The negative of this numbers becomes the exponent of 10. _____

4. Drop the zeros to the left of the left-most non-zero digit. _____

Express 0.000902 in scientific notation

1. Write the number without the decimal point. _____

2. Place the decimal so that the first number is 1 or more, but less than 10. _____

3. Count how many places you had to move the decimal point. The negative of this numbers becomes the exponent of 10. _____

4. Drop the zeros to the left of the left-most non-zero digit. _____

Express 0.0000012 in scientific notation

1. Write the number without the decimal point. _____

2. Place the decimal so that the first number is 1 or more, but less than 10. _____

3. Count how many places you had to move the decimal point. The negative of this numbers becomes the exponent of 10. _____

4. Drop the zeros to the left of the left-most non-zero digit. _____

18 Write 0.000847 in scientific notation.

- A 8.47×10^{4}
- B 847×10^{-4}
- C 8.47×10^{-4}
- D 84.7×10^{-5}

Converting to Standard Form

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Express 3.5×10^{4} in standard form

1. Write the coefficient.	3.5
2. Add a number of zeros equal to the exponent: to the right for positive exponents and to the left for negative.	3.50000
3. Move the decimal the number of places indicated by the exponent: to the right for positive exponents and to the left for negative.	35000.0
4. Drop unnecessary zeros and add comma, as necessary.	35,000

Express 1.02×10^{6} in standard form

1. Write the coefficient. _____

2. Add a number of zeros equal to the exponent: to the right for positive exponents and to the left for negative. _____

3. Move the decimal the number of places indicated by the exponent: to the right for positive exponents and to the left for negative. _____

4. Drop unnecessary zeros and add comma, as necessary. _____

Express 3.42×10^{-3} in standard form

1. Write the coefficient. _____

2. Add a number of zeros equal to the exponent: to the right for positive exponents and to the left for negative. _____

3. Move the decimal the number of places indicated by the exponent: to the right for positive exponents and to the left for negative. _____

4. Drop unnecessary zeros and add comma, as necessary. _____

Express 2.95×10^{-4} in standard form

1. Write the coefficient. _____

2. Add a number of zeros equal to the exponent: to the right for positive exponents and to the left for negative. _____

3. Move the decimal the number of places indicated by the exponent: to the right for positive exponents and to the left for negative. _____

4. Drop unnecessary zeros and add comma, as necessary. _____

19 How many times do you need to move the decimal and which direction to change 7.41×10^{-6} into standard form?

- A 6 to the right
- B 6 to the left
- C 7 to the right
- D 7 to the left

20 How many times do you need to move the decimal and which direction to change 4.5×10^{10} into standard form?

- A 10 to the right
- B 10 to the left
- C 11 to the right
- D 11 to the left

21 Write 6.46×10^{4} in standard form.

- A 646,000
- B 0.00000646
- C 64,600
- D 0.0000646

22 Write 3.4×10^3 in standard form.

- A 3,400
- B 340
- C 34,000
- D 0.0034

23 Write 6.46×10^{-5} in standard form.

- A 646,000
- B 0.00000646
- C 0.00646
- D 0.0000646

24 Write 1.25×10^{-4} in standard form.

- A 125
- B 0.000125
- C 0.00000125
- D 4.125

25 Write 4.56×10^{-2} in standard form.

- A 456
- B 4560
- C 0.00456
- D 0.0456

26 Write 1.01×10^{9} in standard form.

- A 101,000,000,000
- B 1,010,000,000
- C 0.00000000101
- D 0.000000101

Comparing Numbers Written in Scientific Notation

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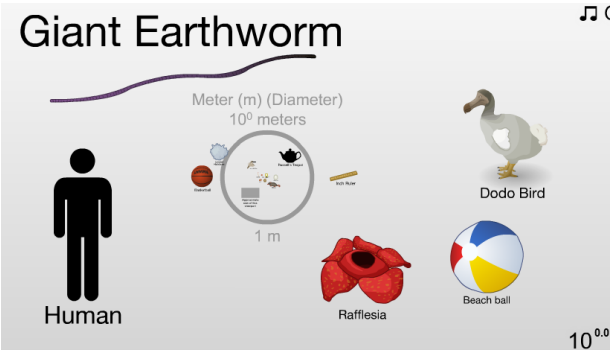
The Scale of the Universe 2



Comparing numbers in scientific notation

First, compare the exponents.

If the exponents are different, the coefficients don't matter; they have a smaller effect.

Whichever number has the larger exponent is the larger number.

Comparing numbers in scientific notation

When the exponents are different, just compare the exponents.

< = >

9.99×10^3 ◯ 2.17×10^4

1.02×10^2 ◯ 8.54×10^{-3}

6.83×10^{-9} ◯ 3.93×10^{-2}

just drag the sign that is correct

Comparing numbers in scientific notation

If the exponents are the same, compare the coefficients.

The larger the coefficient, the larger the number
(if the exponents are the same).

Comparing numbers in scientific notation

When the exponents are the same, just compare the coefficients.

	< = >	
5.67×10^{3}	◯	4.67×10^{3}
4.32×10^{6}	◯	4.67×10^{6}
2.32×10^{10}	◯	3.23×10^{10}

27 Which is ordered from least to greatest?

A I, II, III, IV

B IV, III, I, II

C I, IV, II, III

D III, I, II, IV

I. 1.0×10^{5}

II. 7.5×10^{6}

III. 8.3×10^{4}

IV. 5.4×10^{7}

28 Which is ordered from least to greatest?

- A I, II, III, IV
- B IV, III, I, II
- C I, IV, II, III
- D I, II, IV, III

I. 1.0×10^{2}

II. 7.5×10^{6}

III. 8.3×10^{9}

IV. 5.4×10^{7}

29 Which is ordered from least to greatest?

- A I, II, III, IV
- B IV, III, I, II
- C III, IV, II, I
- D III, IV, I, II

I. 1×10^{2}

II. 7.5×10^{3}

III. 8.3×10^{-2}

IV. 5.4×10^{-3}

30 Which is ordered from least to greatest?

- A II, III, I, IV
- B IV, III, I, II
- C III, IV, II, I
- D III, IV, I, II

I. 1×10^{-2}

II. 7.5×10^{-24}

III. 8.3×10^{-15}

IV. 5.4×10^{2}

31 Which is ordered from least to greatest?

- A I, II, III, IV
- B IV, III, I, II
- C I, IV, II, III
- D III, IV, I, II

I. 1.0×10^2

II. 7.5×10^2

III. 8.3×10^2

IV. 5.4×10^2

32 Which is ordered from least to greatest?

- A I, II, III, IV
- B IV, III, I, II
- C I, IV, II, III
- D III, IV, I, II

I. 1.0×10^6

II. 7.5×10^6

III. 8.3×10^6

IV. 5.4×10^7

33 Which is ordered from least to greatest?

- A I, II, III, IV
- B IV, III, I, II
- C I, IV, II, III
- D III, IV, I, II

I. 1.0×10^3

II. 5.0×10^3

III. 8.3×10^6

IV. 9.5×10^6

34 Which is ordered from least to greatest?

- A I, II, III, IV
- B IV, III, I, II
- C I, IV, II, III
- D III, IV, I, II

I. 2.5×10^{-3}

II. 5.0×10^{-3}

III. 9.2×10^{-6}

IV. 4.2×10^{6}

Multiplying Numbers in Scientific Notation

Multiplying with scientific notation requires at least three (and sometimes four) steps.

1. Multiply the coefficients
2. Add the powers of ten
3. Combine those results
4. Put in proper form

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Multiplying Numbers in Scientific Notation

Evaluate: $(6.0 \times 10^{4})(2.5 \times 10^{2})$

1. Multiply the coefficients	**$6.0 \times 2.5 = 15$**
2. Add the powers of ten	**$10^{4} \times 10^{2} = 10^{6}$**
3. Combine those results	**15×10^{6}**
4. Put in proper form	**1.5×10^{7}**

Multiplying Numbers in Scientific Notation

Evaluate: $(4.80 \times 10^{6})(9.0 \times 10^{-8})$

1. Multiply the coefficients _____
2. Add the powers of ten _____
3. Combine those results _____
4. Put in proper form _____

35 Evaluate $(2.0 \times 10^{-4})(4.0 \times 10^{7})$. Express the result in scientific notation.

- A 8.0×10^{11}
- B 8.0×10^{3}
- C 5.0×10^{3}
- D 5.0×10^{11}
- E 7.68×10^{-28}
- F 7.68×10^{-28}

36 Evaluate $(5.0 \times 10^{6})(7.0 \times 10^{7})$

- A 3.5×10^{13}
- B 3.5×10^{14}
- C 3.5×10^{1}
- D 3.5×10^{-1}
- E 7.1×10^{13}
- F 7.1×10^{1}

37 Evaluate $(6.0 \times 10^{2})(2.0 \times 10^{3})$

- A 1.2×10^{6}
- B 1.2×10^{1}
- C 1.2×10^{5}
- D 3.0×10^{-1}
- E 3.0×10^{5}
- F 3.0×10^{1}

38 Evaluate $(1.2 \times 10^{-6})(2.5 \times 10^{3})$. Express the result in scientific notation.

- A 3×10^{3}
- B 3×10^{-3}
- C 30×10^{-3}
- D 0.3×10^{-18}
- E 30×10^{18}

39 Evaluate $(1.1 \times 10^{4})(3.4 \times 10^{6})$. Express the result in scientific notation.

- A 3.74×10^{24}
- B 3.74×10^{10}
- C 4.5×10^{24}
- D 4.5×10^{10}
- E 37.4×10^{24}

40 Evaluate $(3.3 \times 10^4)(9.6 \times 10^3)$. Express the result in scientific notation.

- A 31.68×10^7
- B 3.168×10^8
- C 3.2×10^7
- D 32×10^8
- E 30×10^7

41 Evaluate $(2.2 \times 10^{-5})(4.6 \times 10^{-4})$. Express the result in scientific notation.

- A 10.12×10^{-20}
- B 10.12×10^{-9}
- C 1.012×10^{-10}
- D 1.012×10^{-9}
- E 1.012×10^{-8}

Dividing Numbers in Scientific Notation

Dividing with scientific notation follows the same basic rules as multiplying.

1. Divide the coefficients

2. Subtract the powers of ten

3. Combine those results

4. Put in proper form

Division with Scientific Notation

Evaluate: $\frac{5.4 \times 10^6}{9.0 \times 10^2}$

1. Divide the coefficients — $5.4 \div 9.0 = 0.6$
2. Subtract the powers of ten — $10^6 \div 10^2 = 10^4$
3. Combine those results — 0.6×10^4
4. Put in proper form — 6.0×10^3

Division with Scientific Notation

Evaluate: $\frac{4.4 \times 10^6}{1.1 \times 10^3}$

1. Divide the coefficients _____
2. Subtract the powers of ten _____
3. Combine those results _____
4. Put in proper form _____

42 Evaluate $\frac{4.16 \times 10^{-9}}{5.2 \times 10^{-5}}$

Express the result in scientific notation.

- ❍ A 0.8×10^{-4}
- ❍ B 0.8×10^{-14}
- ❍ C 0.8×10^{-5}
- ❍ D 8×10^{-4}
- ❍ E 8×10^{-5}

43 Evaluate $\frac{7.6 \times 10^{-2}}{4 \times 10^{-4}}$

Express the result in scientific notation.

- A 1.9×10^{-2}
- B 1.9×10^{-6}
- C 1.9×10^{2}
- D 1.9×10^{-8}
- E 1.9×10^{8}

44 Evaluate $\frac{8.2 \times 10^{3}}{2 \times 10^{7}}$

Express the result in scientific notation.

- A 4.1×10^{-10}
- B 4.1×10^{4}
- C 4.1×10^{-4}
- D 4.1×10^{21}
- E 4.1×10^{10}

45 Evaluate $\frac{3.2 \times 10^{-2}}{6.4 \times 10^{-4}}$

Express the result in scientific notation.

- A $.5 \times 10^{-6}$
- B $.5 \times 10^{-2}$
- C $.5 \times 10^{2}$
- D 5×10^{1}
- E 5×10^{3}

46 **The point on a pin has a diameter of approximately 1×10^{-4} meters. If an atom has a diameter of 2×10^{-10} meters, about how many atoms could fit across the diameter of the point of a pin?**

- ❍ **A** **50,000**
- ❍ **B** **500,000**
- ❍ **C** **2,000,000**
- ❍ **D** **5,000,000**

Question from ADP Algebra I End-of-Course Practice Test

Addition and Subtraction with Scientific Notation

Numbers in scientific notation can only be added or subtracted if they have the same exponents.

If needed, an intermediary step is to rewrite one of the numbers so it has the same exponent as the other.

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Addition and Subtraction

This is the simplest example of addition

$$4.0 \times 10^3 + 5.3 \times 10^3 =$$

Since the exponents are the same (3), just add the coefficients.

$$4.0 \times 10^3 + 5.3 \times 10^3 = 9.3 \times 10^3$$

This just says

$$\begin{array}{r} 4.0 \text{ thousand} \\ +\ 5.3 \text{ thousand} \\ \hline 9.3 \text{ thousand.} \end{array}$$

Addition and Subtraction

This problem is slightly more difficult because you need to add one extra step at the end.

$8.0 \times 10^3 + 5.3 \times 10^3 =$

Since the exponents are the same (3), just add the coefficients.

$8.0 \times 10^3 + 5.3 \times 10^3 = 13.3 \times 10^3$

But that is not proper form, since 13.3 > 10;
it should be written as 1.33×10^4

Addition and Subtraction

$8.0 \times 10^4 + 5.3 \times 10^3 =$

This requires an extra step at the beginning because the exponents are different. We have to either convert the first number to 80×10^3 or the second one to 0.53×10^4.

The latter approach saves us a step at the end.

$8.0 \times 10^4 + 0.53 \times 10^4 = 8.53 \times 10^4$

Once both numbers had the same exponents, we just add the coefficient. Note that when we made the exponent 1 bigger, coefficient. Note that when we made the exponent 1 bigger, that's makes the number 10x bigger; we had to make the coefficient 1/10 as large to keep the number the same.

47 The sum of 5.6×10^3 and 2.4×10^3 is

- ❍ **A** 8.0×10^3
- ❍ **B** 8.0×10^6
- ❍ **C** 8.0×10^{-3}
- ❍ **D** 8.53×10^3

48 8.0×10^3 minus 2.0×10^3 is

- A 6.0×10^{-3}
- B 6.0×10^0
- C 6.0×10^3
- D 7.8×10^3

49 7.0×10^3 plus 2.0×10^2 is

- A 9.0×10^3
- B 9.0×10^5
- C 7.2×10^3
- D 7.2×10^2

50 3.5×10^5 plus 7.8×10^5 is

- A 11.3×10^5
- B 1.13×10^4
- C 1.13×10^6
- D 11.3×10^{10}