Scientific Notation and Significant Figures Name _____

I set this page up so students would guess before writing the answer, because many students understand negative exponents incorrectly. For AP students, you can just write the answer without guessing first.

Part A: Powers of Ten

	My Guess	The Answer
$10^1 =$ $10^2 =$ $10^3 =$ $10^4 =$ $10^5 =$		
$10^0 =$		
$10^{-1} =$ $10^{-2} =$ $10^{-3} =$ $10^{-4} =$ $10^{-5} =$		

Rule for 0^{th} Powers:

The 0^{th} power of anything is *always* equal to 1.

Rule for Negative Powers:

A negative exponent is equal to the inverse of the same number with a positive exponent.

$$18^{-5} = \frac{1}{18^5}$$

A.1 10^4 =

A.2 10^{-3} =

A.3 Give 3 different ways to write 10^{-5}:

A.4 True or false? If a positive number is raised to a negative power, it is a negative number.

A.5 What is any number to the 0^{th} power?

A.6 213213251090.31415135^0 =

A.7 Whole numbers with negative exponents become _____.

Part B: Scientific Notation to Standard Notation:

Label the *significant figures* (also called the coefficient) and the *order of magnitude* in this scientific notation number:

3.45×10^6

What is scientific notation?

A way of writing very large and very small numbers shortly by multiplying by powers of 10.

Why do we care about scientific notation?

Some of the most interesting things in physics are either VERY BIG or VERY SMALL, and can be understood more easily with scientific notation.

Converting Scientific notation to standard notation

Rule #1

Move the decimal point to the RIGHT if the exponent is POSTIVE, and to the LEFT if the exponent is NEGATIVE

POSITIVE exponent = makes a BIG NUMBER = moves RIGHT
NEGATIVE exponent = makes a DECIMAL = moves LEFT

Rule #2

Move the decimal point as many spots as the exponent.

Convert each number to standard notation

A) 3.45×10^{4} =

B) 4.23×10^{7} =

C) 9.12×10^{2} =

D) 4.87×10^{5} =

E) 8.25×10^{6} =

F) 2.45×10^{0} =

G) 2.54×10^{1} =

H) 3.89×10^{0} =

I) 4.23×10^{-3} =

J) 3.28×10^{-8} =

K) 6.78×10^{-5} =

L) 3.85×10^{-4} =

M) 5.28×10^{-7} =

O) 3.42×10^{5} =

P) 4.23×10^{2} =

Q) What is 1 advantage of scientific notation over standard notation?

R) What do we sometimes call the exponent in scientific notation?

S) What do we sometimes call the digits in scientific notation?

Part C: Standard Notation to Scientific Notation

Step #1: Move the decimal place until it is in the correct location. There should be exactly ONE digit to the left of the decimal point.
Step # 2: Is it a BIG NUMBER? Then, you have a POSITIVE exponent, (and the decimal point moved left.). Is it a decimal? Then, you have a NEGATIVE exponent. (and the decimal point moved right) BIG NUMBER = LEFT = POSITIVE exponent LITTLE NUMBER = RIGHT = NEGATIVE exponent
Step #3 The value of the exponent should be the number of times you moved the decimal point.

NOT scientific notation	Scientific notation!	NOT scientific notation
$.456 \times 10^6$	4.56×10^5	45.6×10^4

For each number, switch it from standard notation to scientific notation.

A 3420000

B 32400

C 5830000000

D 1230

E 14

F 9

G 0.00000123

H 0.000145

I 0.000000000123

J 0.0000001241

K 11240000

L 81

M 7

N 990000

P 0.141

Q 0.132

Part D: The Metric System

The metric system is a way of representing numbers based upon powers of ten. This makes it very easy to go between metric and scientific notation.

Prefix	Symbol	Means
peta	P	10^{15}
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
hecto	h	10^{2}
deca	da	10^{1}
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}

Convert each metric number to meters scientific notation:

A) 5.0 kilometers

B) 4.0 femtometers

C) 2.0 terameters

Convert each scientific notation number to metric:

D) 8.0×10^{-9} meters

E) 4.3×10^{-6} meters

F) 5.6×10^{6} meters

Part E: Going from Numbers "in limbo" or metric to scientific notation

When is a number scientific?

A number is in scientific notation ONLY if there is exactly one nonzero digit to the left of the decimal.

Numbers stuck in limbo:

If there are more than one digit to the left, or if there are zero digits to the left, it is NOT in scientific notation. It is stuck in limbo.

(WARNING: This is Mr. Kuncik's word, it isn't a standard math definition people elsewhere will understand. The proper, mathematical term is probably "exponential form but not scientific notation")

NOT scientific notation	Scientific notation!	NOT scientific notation
$.456 \times 10^6$	4.56×10^5	45.6×10^4

For each number say whether it is in scientific notation, standard notation, or in limbo. which are scientific notation, and which are stuck in limbo:

A. 3.42×10^4 **B.** 9.23×10^8 **C.** 0.414×10^5

D. 0.0070×10^1 **E.** 1.10×10^0 **F.** $921. \times 10^4$

G. 11.38×10^5 **H.** 6.0×10^9 **I.** 34.4×10^1

J. 746.2×10^{15} K. 0.097×10^5 **L.** 56.7×10^{11}

How to change limbo to scientific notation:

1. Move the decimal point to the correct location.
2a. Every time you move the decimal LEFT, you INCREASE the exponent by 1.
2b. Every time you move the decimal RIGHT, you DECREASE the exponent by 1.

LEFT = INCREASE exponent
RIGHT = DECREASE exponent

When do you use this?

Sometimes, at the end of a long problem, you have a number in limbo. You need to put in into scientific notation for the answer.

Put the numbers into scientific notation. Or, indicate that they are already in scientific notation.

M. 3.42×10^{4} **N.** 9.23×10^{8}

O. $.414 \times 10^{5}$ **P.** 0.0070×10^{-5}

Q. 1.10×10^{0} **R.** $921. \times 10^{4}$

S. 11.38×10^{5} **T.** 6.0×10^{9}

U. 34.4×10^{1} **V.** 746.2×10^{15}

W. 0.097×10^{5} **X.** 56.7×10^{11}

Metric System to Scientific Notation

Each of these metric system numbers needs to be converted to an SI unit. FIRST, write it using multiplication by a power of 10. THEN, make sure it is in proper scientific notation with the SI unit.

1. I ran 12 kilometers. [SI unit is meters]

2. A human hair has a width of 17 μm. [SI unit is meters]

3. A large city uses 12 terawatts of power. [SI unit is watts]

4. The protist *Eugiena gracilis* has a length of 50 μm. [SI unit is meters]

5. The color GREEN has a frequency of 600 Terahertz and a wavelength of 550 nm. [SI units are hertz and meters]

6. The color RED has a frequency of 480 Terahertz and a wavelength of 750 nm. [SI units are hertz and meters.]

7. The highest sound heard by a cat has a frequency of 64 kilohertz. [SI unit is hertz]

8. There are 4811 kilometers on the drive from Boston to Los Angeles. [SI unit is meters]

Part F: Significant Figures

Significant Figure: A digit that, when giving the answer to a question, you claim to *know*.
How many significant figures? COUNT *every* digit after the first nonzero digit on the left. ZEROS *can* be significant figures, if they are to the *right* of the first nonzero.
One Extra Rule In a *whole number*, any zeros at the end are NOT significant, unless the number ends a decimal point.

How many significant figures are there in each number?

A. 42

B. 42.35

C. 042.0

D. 5.97219×10^{24} kg

E. 0.00540

F. 42.3

G. 42.0

H. 2.99×10^{3}

I. 4.560×10^{-3} kg

J. 0.0000004

In physics:
42 inches means….I know it's 42, but it might be 42.0, or 42.1, or 42.2, etc. I don't know the next decimal point.
42.0 inches….I absolutely know that the tenths place is zero. It is 42.0. But I don't know if it is 42.00, 42.01, or 42.02, etc.
42.00 inches means…I absolutely know that there are two zero decimals. I don't know the third decimal.
Zeros are significant because they communicate information you are sure is true.

K. Why are some zeroes significant figures?

In L and M, Round to 2 significant figures:
L. 1.0000000000

M. 3.33333333333

N. Solve this problem and write the answer with only 2 significant figures: 2/9

In O – S: Round every number to 3 significant figures in scientific notation:
Hint: *first* put the number into scientific notation.
THEN round to 3 significant figures

O. 141231

P. 12412090184

Q. 809707042

R. 0.00000141240918

S. 0.0001241241

Part G: Answering Formula Questions with Significant Figures

Answering questions:
Whenever you write the answer to a question, answer with the LOWEST number of significant figures there are in the numbers

d = vt

T. I move a distance of 52.6 meters in a time of 23.7 seconds.
How many significant figures are there in the distance?

How many significant figures are there in the time?

How many should there be in the answer?

Find the speed:

Looking For	Formula
Already Know	
Answer in a complete sentence with correct significant figures	

U. I move at a speed of about 3 m/s for a time of 345.6 seconds.
How many significant figures are there in the speed?

How many significant figures are there in the time?

How many should there be in the answer? You will need to use scientific notation!

Find the distance:

Looking For	Formula
Already Know	
Answer in a complete sentence with correct significant figures	

V. I move at a speed of 4.32165 m/s for a time of 1.2345 seconds.
How many significant figures are there in the speed?

How many significant figures are there in the time?

How many should there be in the answer?

Find the distance:

Looking For	Formula
Already Know	
Answer in a complete sentence with correct significant figures	

$$KE = \frac{1}{2}mv^2$$

W. I have a speed of 3.2 m/s and a mass of 45.678 kg.
How many significant figures should there be in the answer?

Find the kinetic energy:

Looking For	Formula
Already Know	
Answer in a complete sentence with correct significant figures	

X. I have a speed of 3.55 m/s and a mass of 2 kg. What is my kinetic energy?

Y. I have a speed of 3.0000 m/s and a mass of 2.0000. What is my kinetic energy?

Z. What makes problems X and Y different?

$$GPE = mgh \qquad \textbf{g = 9.8 m/s/s}$$

AA.[**Trick question, don't get fooled!]** I have a height of 12.0000 meters and a mass of 3.00000 kg. What is my gravitational potential energy, with the correct number of significant figures?

Part A: Powers of 10 ANSWERS

$10^1 = 10$
$10^2 = 100$
$10^3 = 1000$
$10^4 = 10000$
$10^5 = 100000$

$10^0 = 1$

$10^{-1} = 0.1 = \frac{1}{10}$

$10^{-2} = 0.01 = \frac{1}{100}$

$10^{-3} = 0.001 = \frac{1}{1000}$

$10^{-4} = 0.0001 = \frac{1}{10000}$

$10^{-5} = 0.00001 = \frac{1}{100000}$

A.1 10000

A.2 0.001

A.3 $0.00001 = \frac{1}{100000} = \frac{1}{10^5}$

A.4 False

A.5 1

A.6 1

A.7 fractions or decimals

Part B: Scientific Notation and Standard Notation ANSWERS

A) 34500

B) 42300000

C) 912

D) 487000

E) 8250000

F) 2.45

G)25.4

H) 3.89

I) 0.00423

J) 0.0000000328

K) 0.0000678

L) 0.000385

M) 0.000000528

O) 342000

P) 423

Q) Very large and very small numbers can be written in much less space.

R) The order of magnitude.

S) The coefficient or the significant figures.

Part C: Standard Notation to Scientific Notation ANSWERS

For each number, switch it from standard notation to scientific notation.

A $3.42 \cdot 10^{6}$

B $3.24 \cdot 10^{4}$

C $5.89 \cdot 10^{9}$

D $1.23 \cdot 10^{3}$

E $1.4 \cdot 10^{1}$

F $9 \cdot 10^{0}$ (or just 9)

G $1.23 \cdot 10^{-6}$

H $1.45 \cdot 10^{4}$

I $1.23 \cdot 10^{-10}$

J 1. $1.241 \cdot 10^{-7}$

K $1.124 \cdot 10^{7}$

L $8.1 \cdot 10^{1}$

M $7 \cdot 10^{0}$ (or just 7)

N $9.9 \cdot 10^{5}$

P $1.41 \cdot 10^{-1}$

Q $1.32 \cdot 10^{-1}$

Part D: The Metric System ANSWERS

A) $5.0 \cdot 10^{3}$

B) $4.0 \cdot 10^{-15}$

C) $2.0 \cdot 10^{12}$

D) 8.0 nanometers

E) 4.3 micrometers

F) 5.6 megameters

Part E: Going from Numbers "in limbo" or metric to scientific notation ANSWERS

A. YES in scientific notation **B.** YES **C.** NO, not in scientific notation

D. NO **E.** YES **F.** NO

G. NO **H.** YES **I.** NO

J. NO K. NO **L.** NO

M. YES, 3.42×10^{4} **N.** YES, 9.23×10^{8}

O. NO, 4.14×10^{4} **P.** NO, 7.0×10^{-8}

Q. YES, 1.10×10^{0} **R.** NO, 9.21×10^{6}

S. NO, 1.138×10^{4} **T.** YES, 6.0×10^{9}

U. NO, 3.44×10^{0} **V.** NO, 7.462×10^{13}

W. NO, 9.7×10^{3} **X.** NO, 5.67×10^{10}

1. 1.2×10^{4} meters

2. 1.7×10^{-5} meters

3. 1.2×10^{13} watts

4. 5.0×10^{-5} meters

5. 6.00×10^{14} Hertz and 5.50×10^{-7} meters

6. 4.80×10^{14} Hertz and 7.50×10^{-17} meters

7. 6.5×10^{4} Hertz

8. 4.511×10^{6} meters

Part F: Significant Figures ANSWERS

A. 2

B. 4

C. 3

D. 6

E. 3

F. 3

G. 3

H. 3

I. 4

J. 1

K. An extra zero means that you *know* that that digit is precisely zero.

In L and M, Round to 2 significant figures:

L. 1.0

M. 3.3

N. 0.22

In O – S: Round every number to 3 significant figures in scientific notation:
Hint: *first* put the number into scientific notation.
THEN round to 3 significant figures

O. 1.41×10^5

P. 1.24×10^{10}

Q. 8.10×10^8

R. 1.41 x 10^(-6)

S. 1.24×10^{-4}

T.
How many significant figures are there in the distance?
3
How many significant figures are there in the time?
3
How many should there be in the answer?
3

Find the speed:
2.22 m/s

U.
1×10^3 meters
There is only *one* significant figure in the answer because there was only one significant figure in the speed.

V.
5.3351 meters
(there are 5 significant figures in the answer).

W. 2.30×10^2 Joules

X. 1×10^1 Joules (there is only one significant figure because there was only one in the mass)

Y. 12.638 Joules

Z. The number of significant figures in the answer

AA.3.5×10^2 Joules
(if you used $g = 9.8\ m/s^2$, then there are only two significant figures in the answer!)