AP Physics - First Order Stuff

You've decided to take, for whatever reason, AP Physics. Wow! I am ever so impressed. You, unlike the usual lazy, high school student, are making extremely good use of your high school years by taking a class that will actually teach you something as well as offering you a stiff challenge. At this point I should say some positive things about how important physics is and especially what a good deal taking AP Physics would be and all that. AP Physics students should ***not need to be*** coddled and talked into doing things. They should perform amazing feats of brainwork without the instructor having to spend valuable time motivating them – and ask (beg would also be appropriate) for more. In the military we call such people "self starters". To be a self starter is to be a person who can be relied upon to get things done when they needed doing without being told to go out and do the thing. This is what you should be.

AP Physics: "AP" stands for "advanced placement". The specific course you are taken is AP Physics 1. It is an algebra based college level physics course. The curriculum is established by the College Board.

AP Physics Basic Stuff: Unfortunately, before we can really get into the exciting world of physics, we got to get the old basics out of the way – stuff like math, units, measurements, etc.

I assume that you are a hard-working student and have established a fabulous record of academic performance. You've taken chemistry, algebra, possibly pre-calculus, maybe even physics, so you are already familiar with how to do math and science. Most of the material in this section you already know or were at least exposed to (although it may or may not have taken).

So let us begin.

Note: The finger is pointing to things you must know.

Measuring Things: We will use the SI (*system international*) system exclusively. The SI system is also known as the metric system. The standard units are:

Quantity	Unit	Abbreviation
Mass	kilogram	kg
Time	seconds	s
Length	meter	m

All the other units we will make use of are pretty much derived from these three basic units.

To measure large or small things with these units, prefixes are added which alter the value of the unit. Here are the key prefixes that we will use:

Table of Standard Prefixes

Prefix	Symbol	Factor
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}

There are quite a few other prefixes, but hardly anyone uses them. The ones above are the ones you should know.

There will be little memorization for this course. What you have to learn is how to ***use*** physics to solve problems and explain things. It's a pity too, because memorization would be a lot easier. In fact, the first several years you spent in school probably had a whole bunch of memorization for you to do – how to spell words, dates in history, answers to questions, etc. The good students, who became the teacher's pets and got all the A pluses (like you no doubt) were the ones who took the trouble to memorize the answers.

This is good and bad. Good in that the students get A pluses. Bad in that they think that memorizing answers is all there is to being a good student.

Sadly as school progresses, eventually you reach the level where you can't memorize the answers and be successful. In AP Physics what do you memorize? Well, as you will see, not much.

Anyway, the memorization thing doesn't really work all that well in a physics class.

Back to the exciting story of units. After you get through the basic, standard units the rest of them are ***derived units***. This means that they are combinations of other units.

I'm going to make the daring assumption that AP Physics students are all well versed in the SI system.

Here are some of the derived units:

Quantity	Name	Symbol	Unit Equivalent
Speed, velocity			m/s
Acceleration			m/s^2
Frequency	Hertz	Hz	$1/s$ or s^{-1}
Force	Newton	N	$kg \cdot m/s^2$
Pressure	Pascal	Pa	N/m^2
Work, energy, heat	Joule	J	$N \cdot m$ or $kg \cdot m^2/s^2$
Impulse, momentum			$kg \cdot m/s$ or $N \cdot s$
Power	Watt	W	J/s or $N \cdot m/s$ or $kg \cdot m^2/s^3$

Dimensional Analysis: This is a system used for unit conversions.

Dimensional analysis comes in handy whenever you have to do an involved, complicated unit conversion. Simple conversions like centimeters to meters, however, you can just do in your head if you like.

Anyway, the method is taught in chemistry, so you should be familiar with it.

The key idea here is that units are treated like algebra symbols – you can multiply them by each other, divide with them, and often cancel them out.

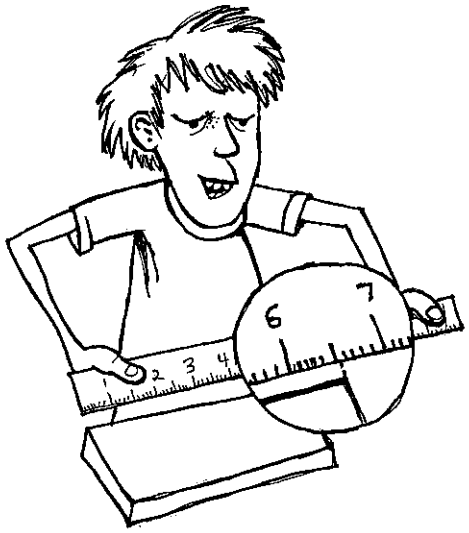
- There are 5 280 ft in one mile, 3.281 feet in one meter, and 3 600 seconds in one hour. Convert 75.0 miles/hour to m/s.

$$75.0 \frac{\cancel{miles}}{\cancel{h}} \left(\frac{5\,280 \cancel{ft}}{1\, \cancel{mile}} \right) \left(\frac{1\, m}{3.281 \cancel{ft}} \right) \left(\frac{1 \cancel{h}}{3\,600\, s} \right) = 33.5 \frac{m}{s}$$

Note the diagonal line through some of the units – these are the units that cancelled. Make sure that you always cancel units where required.

Dimensional analysis is always a good check on whether you've set up a problem properly. Usually if the units work out, then you're solution method is a proper one.

Significant Figures: In physics, unlike your math classes, the numbers we will use in problems are generally measurements. They are not pure numbers. Their accuracy depends on the instrument used to make the measurement. This accuracy is indicated by using significant figures.



So how do you make a measurement and have it properly indicate its accuracy? Well, simple. When you make a measurement, you always write down the numbers from the scale that you know for certain and then you estimate one more number.

For example, suppose you measure a length with a ruler that is marked to the nearest tenth of a centimeter. The object's length reaches between 6.5 and 6.6 centimeters. So you write down "6.5" because you are sure about them – the 6 and the 5. Then you estimate where the object lies between the .5 and .6. This is the final number you write down. You estimate it comes in about three tenths of the way, so your measurement is "6.53 cm".

Rules for Significant Figures: Here are the rules:

1. All ***non zero numbers*** are ***always*** significant.
2. Zeros between non-zero numbers are ***always*** significant.
3. Leading zeros are ***never*** significant.
4. Trailing zeros are ***not significant*** if the number has ***no decimal point***.
5. Trailing zeros ***are significant*** if the number ***has*** a ***decimal point***.
6. The mantissa (number in front of the power of ten) of a number written in scientific notation is ***always*** significant. The power of ten is not.

Here are some examples:		
	25.2 cm	3 significant figures (rule 1)
	35.0 s	3 significant figures (rules 1 and 5)
	0.0044 kg	2 significant figures (rules 1 and 3)
	30200 m	3 significant figures (rules 1, 2, and 4)
	2.5×10^{12} J	2 significant figures (rules 1 and 6)

Using Significant Figures in Calculations: When making calculations, the mathematical process can generate a great many numbers that would make the answer more precise than the data. Clearly that must not be allowed. When you divide one by three, for example, you get a decimal point followed by a whole slew of threes – as many as your calculator can display. To preserve the accuracy of a calculated value, one uses rules for mathematical operations with significant figures. They are quite simple.

Multiplying or dividing – the number of significant figures in the answer must be the same as the number of significant figures for the least accurate measurement used in the problem.

Adding or subtracting – the number of decimal places in the answer must be the same as the smallest number of decimal places in the measurements used to make the calculation.

Examples:

1. 2.500 m + 1.21 m + 3.4561 m – 245.1 m = - 237.9339 m

   The answer must be rounded off to the nearest tenth as 245.1 has only one decimal place.

   The answer is – 237.9 m

2. $$\frac{345\ N(12\ \cancel{m})}{5.005\ \cancel{m}} = 827.1728\ N = 830\ N$$

The answer must be rounded off so that it only has two significant figures because 12 m, one of the measurements, only has two significant figures.

Rounding Off: You run into a rounding off problem when rounding off a number that ends in five. Do you round up or do you leave it alone? In physics, you round up if the number in front of the five is odd. If the number in front of the five is even, you don't round up. Let's do an example. You've gotten an answer of 25.500 m that has to be rounded off to two significant figures. 25.500 m would round off to 26 m, since the number in front of the five is odd. But 24.500 m would round off to 24 m.

You only use this rule if the last nonzero number is five. If there is anything else you would round up. For example you have this number 12.25001 m. It's the answer to a problem you are solving and you want three significant figures in the answer. Because of the 1 all the way at the end, the number is more than halfway between 12.2 m and 12.3 m, so you round it up to 12.3 m. Does this make sense? Think about it till it does.

Problem Solving: As an AP Physics student, you will be privileged to solve many problems – many of them quite involved and complicated. You will become a ***master problem solver*** through the course of the year. To help get you started, I am more than happy to provide you with some helpful problem solving hints.

1. Read the problem carefully at least twice.
2. Draw a diagram of the basic situation with labels.
3. Decide on what direction will be positive. Decide on where to place the origin of your coordinate system.
4. Imagine a movie in your mind of what happens. What does your common sense tell you is going to happen?

5. Identify the basic physics principles involved, list the knowns and unknowns provided in the problem.
6. Determine what information is important and what information is extraneous.
7. Draw a free body diagram (if appropriate – more on what a free body diagram is later).
8. Write down or develop the equation(s) needed. Symbolically solve for the unknown.
9. Substitute the given values into the equations you developed.
10. Do the calculations.
11. Now check that all numbers have proper units, that units have been canceled where appropriate, and that the answer has the correct number of significant figures.
12. Reflect upon your work. Ask yourself these questions:

    - Do the units match?
    - Are the units the proper ones
    - Is the answer reasonable – does it make sense?
    - Is a plus or minus sign proper or meaningful?

13. Draw a box or a circle around your answer.

Your work should be written as a logically ordered series of discrete, clearly delineated steps. This will allow another person to follow your method of problem solving. In other words, don't write down your work in a helter-skelter fashion where it's hard to follow what you've done.

Example: Here's a simple chemistry problem. A gas occupies a volume of 2.50 L at a pressure of 1.25 atm. If the pressure is changed to 5.75 atm what is the new volume?

1. Write down the equation, this would, you no doubt recall, be Boyle's law:

$$P_1V_1 = P_2V_2$$

2. Now you must solve the equation for V_2, the new volume:

$$V_2 = \frac{P_1V_1}{P_2}$$ note that no numbers have been used thus far.

3. Next, plug in the values for the data: (This is known as pluggin' and chuggin'.)

$$V_2 = \frac{1.25\ \cancel{atm}(2.50\ L)}{5.75\ \cancel{atm}}$$ (Don't forget to cancel the units!)

4. Write down the answer: $V_2 = 0.543\ L$

5. It needs to have the proper number of significant figures, which it nicely already has, so make a circle around it or make a square around it or something:

$V_2 =$ $\boxed{0.543\ L}$ That's all there is to it.

Physics Definitions:

Kinematics is the study of motion independent of its causes. This simply means that you study movement but you don't worry about what made the movement happen (forces, you will learn in a bit, are the things that make movement happen).

Dynamics is the study of motion and its causes.

A ***scalar*** is a quantity (something you can measure) that has magnitude only, meaning only a numerical value. Mass, temperature, distance, and density are all examples of scalar quantities.

A ***vector*** is a quantity that has magnitude and direction. Forces, accelerations, and velocities are vector quantities. We'll see how they work in a bit.

Distance is a linear length. It is a scalar quantity.

Displacement is a change in position. It is a vector quantity. It involves a distance and a direction.

Change in displacement is Δx $\Delta x \equiv x_f - x_i$

The triangle means "change in". So "Δx" means "change in x".

Final Thoughts: The handout is pretty much finished. We reviewed and or learned a heck of a lot of material. Now, all you have to do is complete the massive math review before you come to class. Print all the sheets and bring them, completed, to class. Good Luck!!

Name_____

Two-Step Equations

Date_____ Period____

Solve each equation.

1) $6 = \frac{a}{4} + 2$

2) $-6 + \frac{x}{4} = -5$

3) $9x - 7 = -7$

4) $0 = 4 + \frac{n}{5}$

5) $-4 = \frac{r}{20} - 5$

6) $-1 = \frac{5 + x}{6}$

7) $\frac{v + 9}{3} = 8$

8) $2(n + 5) = -2$

9) $-9x + 1 = -80$

10) $-6 = \frac{n}{2} - 10$

11) $-2 = 2 + \frac{v}{4}$

12) $144 = -12(x + 5)$

13) $-15 = -4m + 5$

14) $10 - 6v = -104$

15) $8n + 7 = 31$

16) $-9x - 13 = -103$

17) $\frac{n+5}{-16} = -1$

18) $-10 = -10 + 7m$

19) $-10 = 10(k - 9)$

20) $\frac{m}{9} - 1 = -2$

21) $9 + 9n = 9$

22) $7(9 + k) = 84$

23) $8 + \frac{b}{-4} = 5$

24) $-243 = -9(10 + x)$

Name_____

Multi-Step Equations

Date_____ Period____

Solve each equation.

1) $-20 = -4x - 6x$

2) $6 = 1 - 2n + 5$

3) $8x - 2 = -9 + 7x$

4) $a + 5 = -5a + 5$

5) $4m - 4 = 4m$

6) $p - 1 = 5p + 3p - 8$

7) $5p - 14 = 8p + 4$

8) $p - 4 = -9 + p$

9) $-8 = -(x + 4)$

10) $12 = -4(-6x - 3)$

11) $14 = -(p - 8)$

12) $-(7 - 4x) = 9$

13) $-18 - 6k = 6(1 + 3k)$

14) $5n + 34 = -2(1 - 7n)$

15) $2(4x - 3) - 8 = 4 + 2x$

16) $3n - 5 = -8(6 + 5n)$

17) $-(1 + 7x) - 6(-7 - x) = 36$

18) $-3(4x + 3) + 4(6x + 1) = 43$

19) $24a - 22 = -4(1 - 6a)$

20) $-5(1 - 5x) + 5(-8x - 2) = -4x - 8x$

Name_____

Radical Equations - Part 1

Date_____ Period____

Solve each equation. Remember to check for extraneous solutions.

1) $\sqrt{x} = 10$

2) $10 = \sqrt{\frac{m}{10}}$

3) $\sqrt{v-4} = 3$

4) $6 = \sqrt{v-2}$

5) $\sqrt{n} = 9$

6) $5 = \sqrt{x+3}$

7) $2 = \sqrt{4b}$

8) $\sqrt{n+9} = 1$

9) $-8 + \sqrt{5a-5} = -3$

10) $10\sqrt{9x} = 60$

11) $1 = \sqrt{x-5}$

12) $-10\sqrt{v-10} = -60$

13) $10 + \sqrt{10m - 1} = 13$

14) $-12 = -6\sqrt{b + 4}$

15) $\sqrt{v + 3} - 1 = 7$

16) $90 = 9\sqrt{25v}$

17) $\sqrt{3n} = \sqrt{4n - 1}$

18) $\sqrt{2n - 88} = \sqrt{\frac{n}{6}}$

19) $\sqrt{\frac{x}{10}} = \sqrt{3x - 58}$

20) $\sqrt{3n + 12} = \sqrt{n + 8}$

21) $\sqrt{n} = \sqrt{2n - 6}$

22) $\sqrt{11 - x} = \sqrt{x - 7}$

23) $\sqrt{72 - x} = \sqrt{\frac{x}{5}}$

24) $\sqrt{x + 3} = \sqrt{1 - x}$

25) $\sqrt{2k + 40} = \sqrt{-16 - 2k}$

26) $\sqrt{x + 8} = \sqrt{3x + 8}$

Name_____

Radical Equations - Part 2

Date_____ Period____

Solve each equation. Remember to check for extraneous solutions.

1) $\sqrt{110-n}=n$

2) $p=\sqrt{2-p}$

3) $\sqrt{30-x}=x$

4) $x=\sqrt{8x}$

5) $x=\sqrt{42-x}$

6) $\sqrt{12-r}=r$

7) $\sqrt{4n}=n$

8) $\sqrt{5v}=v$

9) $r=\sqrt{10r}$

10) $m=\sqrt{56-m}$

11) $b=\sqrt{-4+4b}$

12) $r=\sqrt{8r}$

13) $\sqrt{-16+10a}=a$

14) $r=\sqrt{-1-2r}$

15) $\sqrt{-45+14n}=n$

16) $x=\sqrt{110-x}$

17) $\sqrt{9n}=n$

18) $x=\sqrt{40-3x}$

19) $\sqrt{90-n}=n$

20) $x=\sqrt{-70+17x}$

21) $\sqrt{4n+8}=n+3$

22) $-n+\sqrt{6n+19}=2$

23) $4+\sqrt{-3m+10}=m$

24) $x-5=\sqrt{x+1}$

25) $n-7=\sqrt{3n-21}$

26) $b-6=\sqrt{18-3b}$

27) $-3+\sqrt{m+59}=m$

28) $\sqrt{7a-54}-a=-6$

Name_____

Finding Slope From a Graph

Date_____ Period____

Find the slope of each line.

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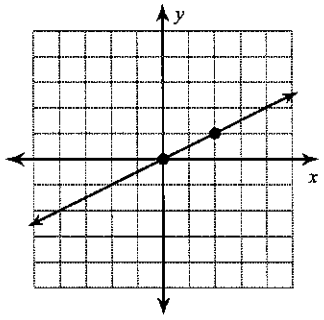

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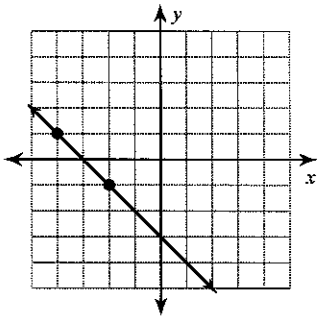

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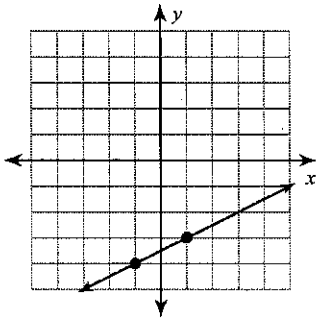

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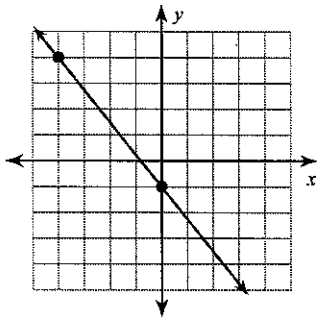

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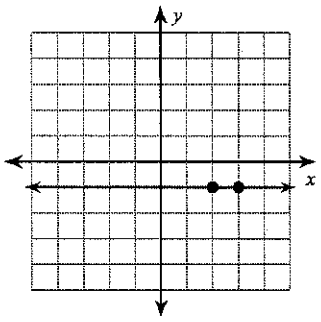

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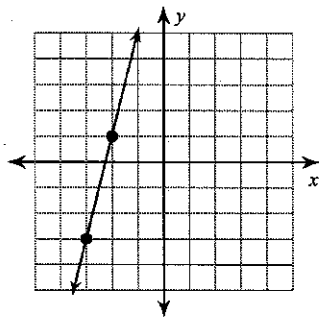

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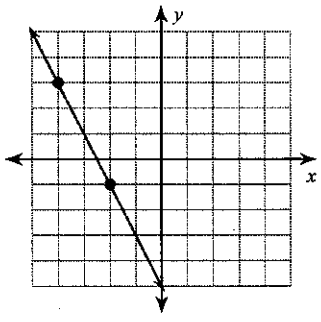

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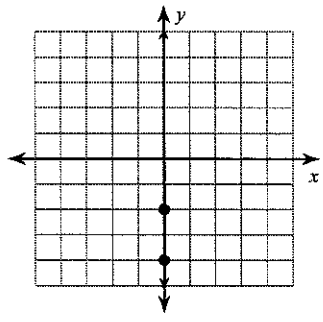

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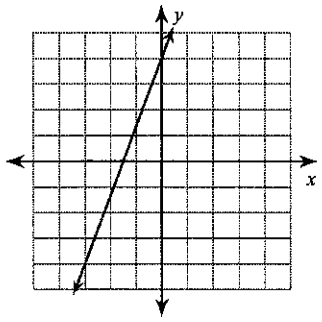

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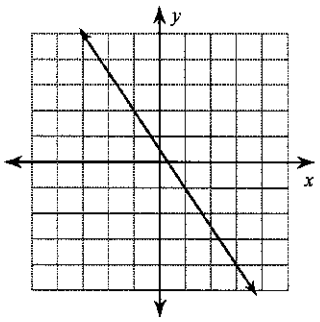

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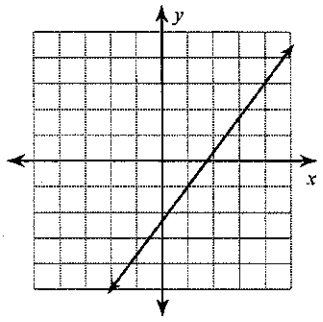

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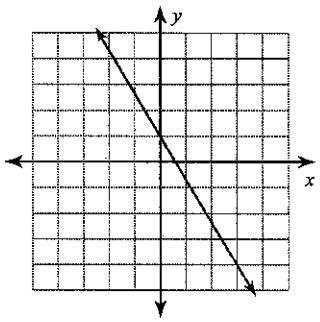

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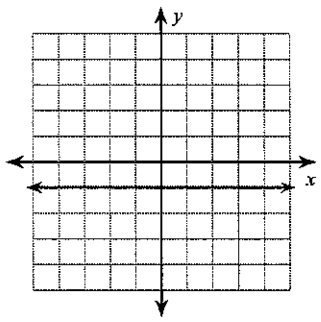

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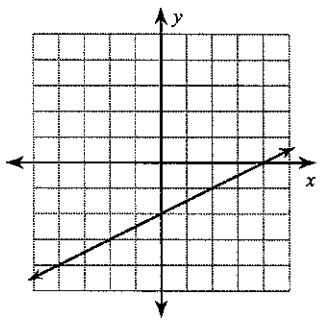

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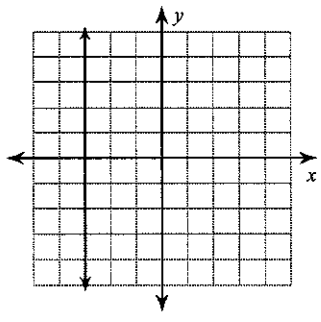

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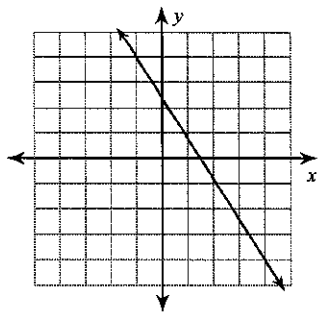

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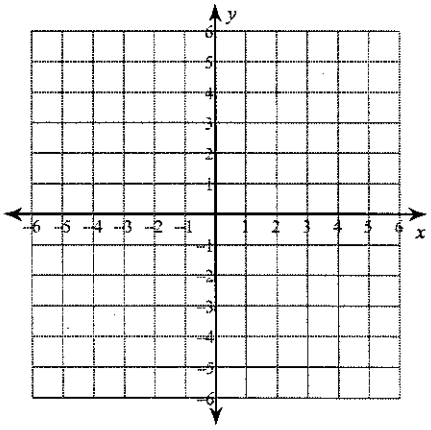
Graphing Lines

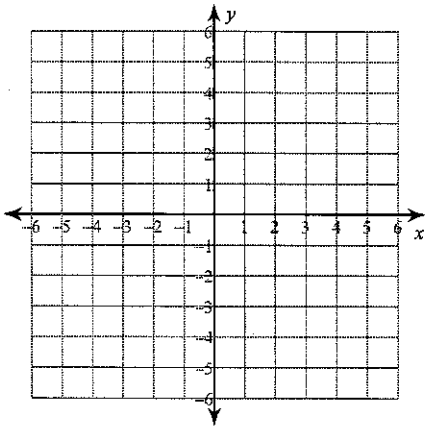
Date_____ Period____

Sketch the graph of each line.

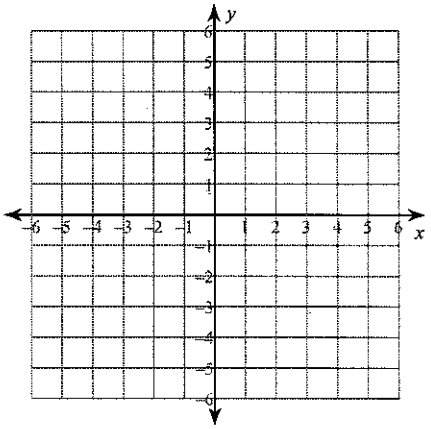
1) $7x + y = 5$



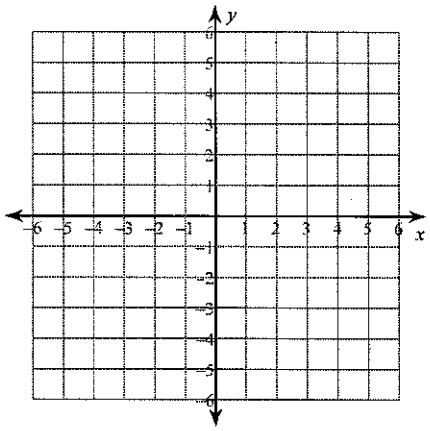
2) $3x + 5y = -5$



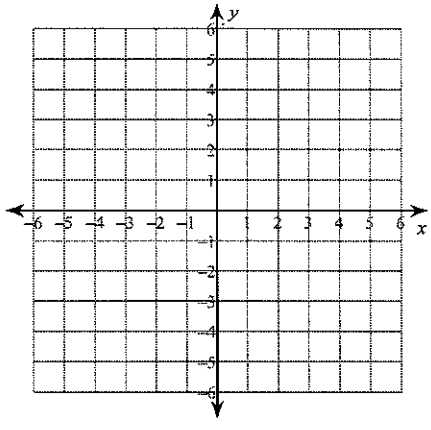
3) $y = 4$



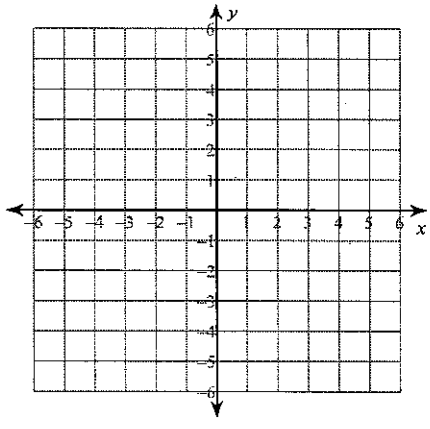
4) $6x + 5y = 20$



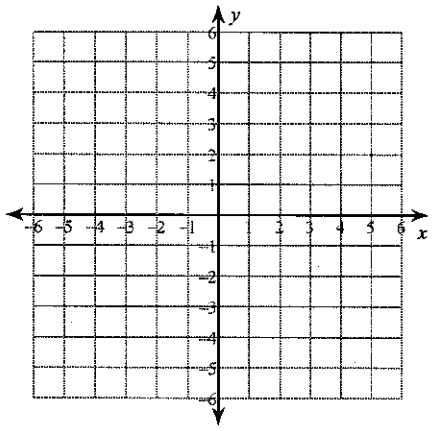
5) $x = -3$



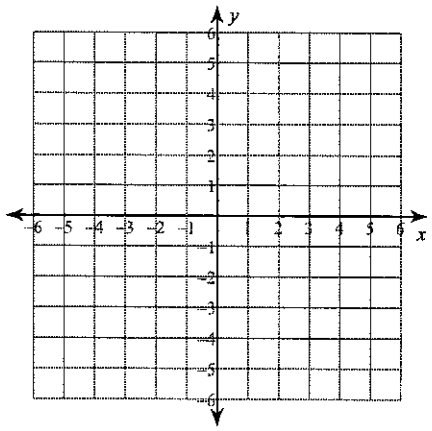
6) $2x + y = 4$



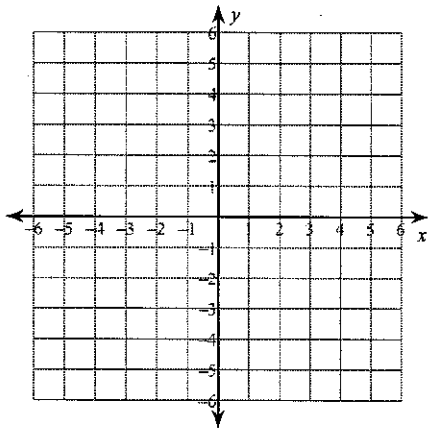
7) $x + y = 3$



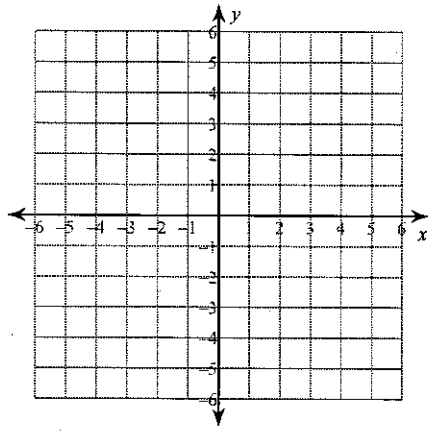
8) $10x - 3y = 15$



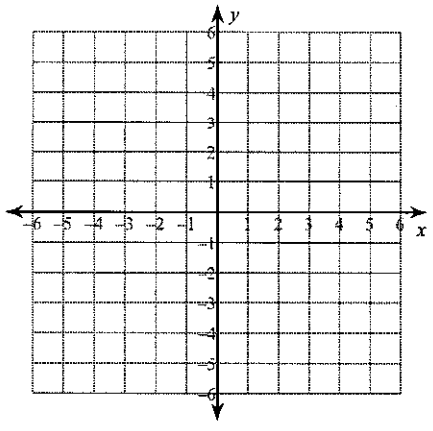
9) $x - y = 3$



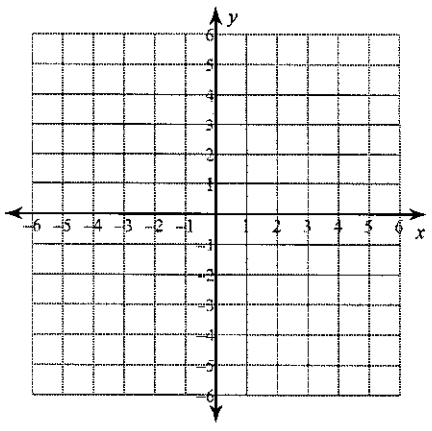
10) $y = 0$



11) $x + y = -3$



12) $x + y = -1$



Name_____

Writing Linear Equations

Date_____ Period____

Write the slope-intercept form of the equation of each line.

1) $3x - 2y = -16$

2) $13x - 11y = -12$

3) $9x - 7y = -7$

4) $x - 3y = 6$

5) $6x + 5y = -15$

6) $4x - y = 1$

7) $11x - 4y = 32$

8) $11x - 8y = -48$

Write the standard form of the equation of the line through the given point with the given slope.

9) through: $(1, 2)$, slope $= 7$

10) through: $(3, -1)$, slope $= -1$

11) through: $(-2, 5)$, slope $= -4$

12) through: $(3, 5)$, slope $= \frac{5}{3}$

13) through: $(2, -4)$, slope $= -1$

14) through: $(2, 5)$, slope = undefined

15) through: $(3, 1)$, slope $= \frac{1}{2}$

16) through: $(-1, 2)$, slope $= 2$

Write the point-slope form of the equation of the line described.

17) through: $(4, 2)$, parallel to $y = -\frac{3}{4}x - 5$

18) through: $(-3, -3)$, parallel to $y = \frac{7}{3}x + 3$

19) through: $(-4, 0)$, parallel to $y = \frac{3}{4}x - 2$

20) through: $(-1, 4)$, parallel to $y = -5x + 2$

21) through: $(2, 0)$, parallel to $y = \frac{1}{3}x + 3$

22) through: $(4, -4)$, parallel to $y = -x - 4$

23) through: $(-2, 4)$, parallel to $y = -\frac{5}{2}x + 5$

24) through: $(-4, -1)$, parallel to $y = -\frac{1}{2}x - 1$

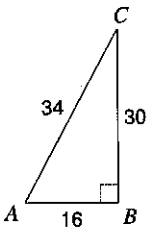
Name_____

Finding Trigonometric Ratios

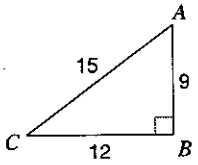
Date_____ Period____

Find the value of each trigonometric ratio to the nearest ten-thousandth.

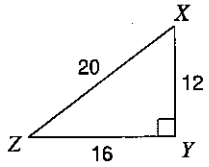
1) tan A



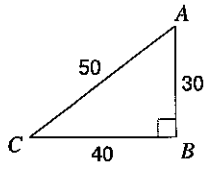
2) cos C



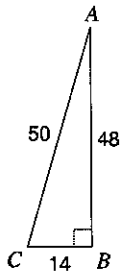
3) sin Z



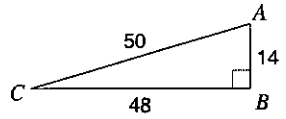
4) sin C



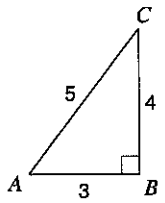
5) sin C



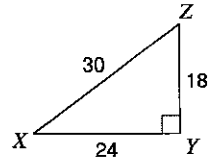
6) sin C



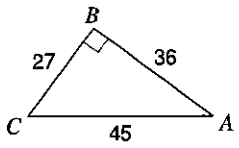
7) cos A



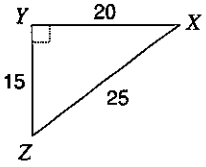
8) cos X



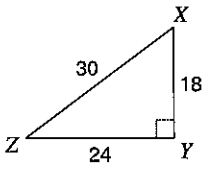
9) cos A



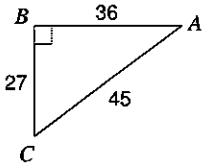
10) cos Z



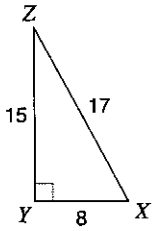
11) sin Z



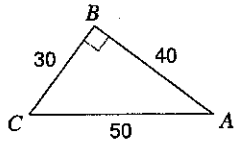
12) sin C



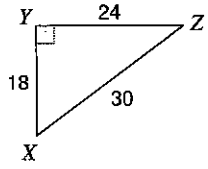
13) cos X



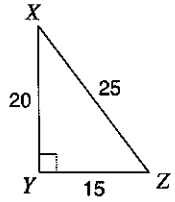
14) tan A



15) tan X



16) tan X



Use a calculator to find the value of each to the nearest ten-thousandth.

17) sin 21°

18) tan 22°

19) cos 20°

20) sin 77°

21) tan 17°

22) cos 87°

Name_____

Using Trigonometry to Find Angle Measures

Date_____ Period____

Find each angle measure to the nearest degree.

1) tan A = 2.0503

2) cos Z = 0.1219

3) tan Y = 0.6494

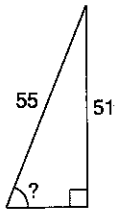
4) sin U = 0.8746

5) cos V = 0.6820

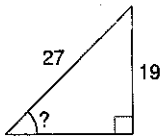
6) sin C = 0.2756

Find the measure of the indicated angle to the nearest degree.

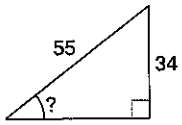
7)



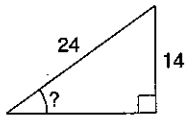
8)



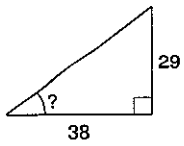
9)



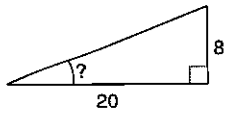
10)



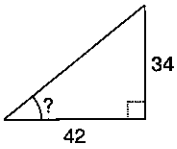
11)



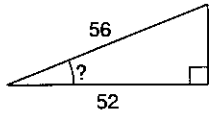
12)



13)



14)



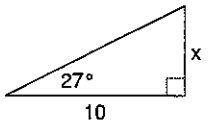
Name_____

Using Trigonometry To Find Lengths

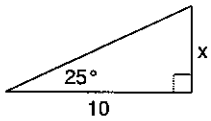
Date_____ Period____

Find the missing side. Round to the nearest tenth.

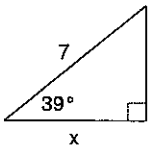
1)



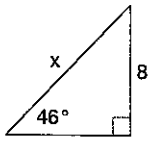
2)



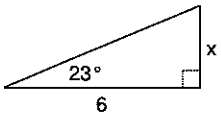
3)



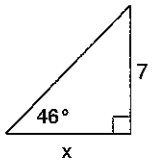
4)



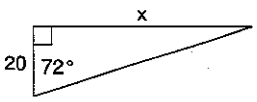
5)



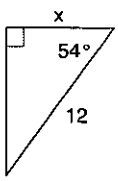
6)



7)



8)



Name_____

Properties of Exponents

Date_____ Period____

Simplify. Your answer should contain only positive exponents.

1) $2m^2 \cdot 2m^3$

2) $m^4 \cdot 2m^{-3}$

3) $4r^{-3} \cdot 2r^2$

4) $4n^4 \cdot 2n^{-3}$

5) $2k^4 \cdot 4k$

6) $2x^3y^{-3} \cdot 2x^{-1}y^3$

7) $2y^2 \cdot 3x$

8) $4v^3 \cdot vu^2$

9) $4a^3b^2 \cdot 3a^{-4}b^{-3}$

10) $x^2y^{-4} \cdot x^3y^2$

11) $(x^2)^0$

12) $(2x^2)^{-4}$

13) $(4r^0)^4$

14) $(4a^3)^2$

15) $(3k^4)^4$

16) $(4xy)^{-1}$

17) $(2b^4)^{-1}$

18) $(x^2y^{-1})^2$

19) $(2x^4y^{-3})^{-1}$

20) $(3m)^{-2}$

21) $\frac{r^2}{2r^3}$

22) $\frac{x^{-1}}{4x^4}$

23) $\frac{3n^4}{3n^3}$

24) $\frac{m^4}{2m^4}$

25) $\frac{3m^{-4}}{m^3}$

26) $\frac{2x^4y^{-4}z^{-3}}{3x^2y^{-3}z^4}$

27) $\frac{4x^0y^{-2}z^3}{4x}$

28) $\frac{2h^3j^{-3}k^4}{3jk}$

29) $\frac{4m^4n^3p^3}{3m^2n^2p^4}$

30) $\frac{3x^3y^{-1}z^{-1}}{x^{-4}y^0z^0}$

Name_____

Writing in Scientific Notation

Date_____ Period____

Write each number in scientific notation.

1) 0.000006

2) 5400000

3) 60

4) 0.009

5) 6.7

6) 0.0000002

7) 2000000

8) 71×10^{3}

9) 48900

10) 0.0000009

11) 0.63×10^{1}

12) 33×10^{-3}

13) 0.000216

14) 0.0042

15) 0.15×10^{-2}

16) 4.8

Name_____

Operations With Scientific Notation

Date_____ Period____

Simplify. Write each answer in scientific notation.

1) $(1.08 \times 10^{-3})(9.3 \times 10^{-3})$

2) $(2 \times 10^{-4})(8.1 \times 10^{-1})$

3) $(2.32 \times 10^{-6})(4 \times 10^{-5})$

4) $(3.48 \times 10^{3})(9.8 \times 10^{4})$

5) $(7.1 \times 10^{-5})(6.7 \times 10^{-6})$

6) $(6 \times 10^{3})(9.91 \times 10^{0})$

7) $\dfrac{7.1 \times 10^{6}}{8.2 \times 10^{1}}$

8) $\dfrac{5.4 \times 10^{-1}}{3.4 \times 10^{1}}$

9) $\dfrac{4 \times 10^{4}}{3.63 \times 10^{-4}}$

10) $\dfrac{9 \times 10^{-5}}{9.24 \times 10^{-6}}$

11) $\dfrac{8.42 \times 10^{3}}{5 \times 10^{2}}$

12) $\dfrac{8.9 \times 10^{6}}{8.4 \times 10^{6}}$

13) $(8.9 \times 10^{5})^{4}$

14) $(4 \times 10^{-5})^{-6}$

15) $(6 \times 10^{-5})^3$

16) $(6.3 \times 10^{2})^{-6}$

17) $(5.21 \times 10^{-5})^2$

18) $(2.4 \times 10^{-5})^4$

19) $\dfrac{3 \times 10^{-2}}{8 \times 10^{-1}}$

20) $\dfrac{4.1 \times 10^{4}}{1.28 \times 10^{-5}}$

21) $\dfrac{1.91 \times 10^{3}}{5 \times 10^{-4}}$

22) $\dfrac{1.62 \times 10^{-6}}{5.3 \times 10^{6}}$

23) $\dfrac{3.59 \times 10^{-2}}{2.22 \times 10^{1}}$

24) $(8.8 \times 10^{-5})^{-5}$

25) $\dfrac{6 \times 10^{-3}}{8.08 \times 10^{-2}}$

26) $(3.5 \times 10^{-2})(9 \times 10^{4})$

27) $(8.8 \times 10^{2})(2.25 \times 10^{-2})$

28) $\dfrac{1.18 \times 10^{-4}}{3 \times 10^{0}}$