AP Physics 1 Information & Summer Assignment 2015

Introduction

Welcome to Mr. Bigler's AP Physics 1 course, which may prove to be one of the most fun & rewarding classes that you will take in high school. However, please be advised that both the course and the AP exam will be challenging. You already know that AP classes are taught as college courses—not just college-*level* courses, but actual college courses. This means that:

- I will do as much as I can to *help* you learn, but you and you alone are responsible for learning and understanding everything covered in class.
- I will give you assignments and fair warning about due dates and test dates, but I will not chase after you. If you were absent and you need to turn in an assignment late, *you* need to find out about the assignment, download it from HAC, do it, and to show it to me; do not assume I will ask you for it.
- If you're having trouble with something, *you* need to be proactive about learning it, either by coming in for help after school, consulting with your classmates, or by getting outside help from somewhere else. This expectation is effective *immediately*, starting with this summer assignment. Remember—*your* job is to succeed; *my* job is to do everything in my power to *help* you be successful, but I can do my job only to the extent that you do yours.

However, even if you do all of the above, the AP Physics 1 exam is not like most other AP exams. For example, the AP Literature exam does not simply test whether you have read and know the plots and characters of dozens of novels; it tests your ability to interpret and write coherently about them. Similarly, the AP Physics 1 exam does not test whether you know the relevant physics concepts and equations, but how well you can apply them to complex problems and situations. The AP Physics 1 exam is at least as much about problem-solving as it is about physics content. Unfortunately, while the Lynn Public Schools have probably taught you to be a decent writer, you have probably learned more about how to *avoid* problem solving ("Whenever you see a problem that looks like this, just memorize and use this formula.") than about how to approach and solve a complex, multi-step problem methodically. For this reason, you may find the AP Physics 1 course and exam to be harder than most (if not all) of the other AP courses and exams that you will take.

Course & Contact Information

Course information: `http://www.mrbigler.com/AP-Physics-1`

Mr. Bigler's email: `biglerj@lynnschools.org`

You can download just about everything you need (including replacement copies of this summer assignment and reference tables) from the website. I will read and respond to email sent to either address throughout the summer and school year.

About the Summer Assignment

The goals of this summer assignment are to give you an introduction to the kinds of thinking you need for AP Physics 1. I expect many of you to struggle with the assignment. I expect many of you to be frustrated with it. I do not expect most of you to be able to do it without help.

The assignment consists of a lab experiment, a set of problems, and a task of inventing your own complex problem and solving it. All parts of this assignment are due on **Monday September 14, 2015**.*

Do not leave this assignment until the last week of vacation. If you do, you will be sorry!

Recommended Supplies

I recommend the following supplies for AP Physics 1:

- **Scientific calculator**. It does not need to be a graphing calculator, though you are welcome to use a graphing calculator if you already have one.
- **AP Physics 1 Class Notes**. These are the same notes that I will project on the SMART board and use in class. You can download an electronic copy (PDF) for free from my website. However, I recommend purchasing a hardcopy, so you can write directly in it throughout the year and take it with you when you go to college. Look for the heading "AP Physics 1 Class Notes" on the class web page, and follow the links for the electronic version and/or the print version (which you can order from `lulu.com`).
- ***Physics Fundamentals* textbook**, by Vincent P. Coletta. This is the textbook that we will be using to supplement the class notes and discussion. You can download a PDF version of the book for free by following the link from the class web page. The username is my last name, and the password is my favorite phrase (all lower case, and including the space). Feel free to ask me or anyone else.
- **AP Physics 1 exam review book**. There are several, all of which have their good points and bad points. I have a slight preference for *Princeton Review* and *SparkNotes*, and I tend to avoid *Baron's*.
- ***The Cartoon Guide to Physics***, by Larry Gonick and Art Huffman. This book is an easy read and it provides excellent visual explanations of all of the topics in AP Physics.

* If your class does not meet on that day, the assignment will be due on the next class day.

Warning about Copying and Other Forms of Cheating

Almost all students copy homework assignments, tests, and anything else they can get away with from each other and from the Internet. AP students do this more than most, because grade-wise, you have the most at stake. However, the more you cheat, the more you limit your learning to only concepts and equations. If you get through the year by copying from other students or the Internet, I can almost guarantee that you will get a 1 on the AP exam, and you will complain that you learned nothing from your AP Physics 1 class.

If I catch you cheating on a test or major assignment, a parent or legal guardian will have to give me permission to let you re-take the test or re-submit the assignment (in either case, for reduced credit). In cases of cheating, you will not be allowed to re-take or re-submit without my having a voice conversation (either by phone or in person) with your parent or guardian first.

Summer Assignment Part 1: Working with Physics Equations

One of the tasks that I will assume you are capable of is determining which quantities are given in a situation (word) problem, finding an equation that relates these quantities, rearranging the equation to solve for the quantity that the problem is asking for, and substituting the correct values into the rearranged equation in order to obtain the answer.

The following are simple one-step problems involving physics concepts that you have not learned yet. To solve each:

A. Look up the variable assigned to the quantities given in the problem and the quantity you need.
B. Find an equation that relates each of the quantities in part A.
C. Rearrange the equation to solve for the quantity you need.
D. Substitute the values of the variables from the problem into your rearranged equation.
E. Calculate the answer and attach the appropriate unit.

You will need your AP Physics 1 equation tables (on the next two pages) for this part

Note that a variable with a subscript "o" means "initially". For example, if a car accelerated from $10\,\frac{\text{m}}{\text{s}}$ to $20\,\frac{\text{m}}{\text{s}}$, then "$v_o$" (the initial velocity) would be $10\,\frac{\text{m}}{\text{s}}$ and "v" (the final velocity) would be $20\,\frac{\text{m}}{\text{s}}$.

Problems

1. What is the velocity, in $\frac{\text{m}}{\text{s}}$, of a car that travels a distance 90. m in a time of 4.5 s?
2. What is the acceleration, in $\frac{\text{m}}{\text{s}^2}$, of a car whose velocity changes from $60.\,\frac{\text{m}}{\text{s}}$ to $80.\,\frac{\text{m}}{\text{s}}$ in a time of 5.0 s?
3. If a force of 100. N acts on a mass of 5.0 kg, what is its acceleration in $\frac{\text{m}}{\text{s}^2}$?
4. What is the potential energy due to gravity, in J, of an anvil with a mass of 95 kg that is about to fall off a cliff that is 150 m high onto Wile E. Coyote's head?
5. A car has a mass of 1200 kg and kinetic energy of 240 000 J. What is the car's velocity in $\frac{\text{m}}{\text{s}}$?
6. If a block has 18 N·s of momentum and a velocity of $3.0\,\frac{\text{m}}{\text{s}}$, what is its mass in kg?
7. An electrical component that has a resistance of 25 Ω has an electric potential of 110 V applied to it. How many amperes (A) of current flow through the resistor?
8. A 1200 W hair dryer is plugged into an electrical circuit with a voltage of 110 V. How much current, in amperes (A), flows through the hair dryer?
9. What is the frequency, in Hz, of a wave that is traveling at a velocity of $300.\,\frac{\text{m}}{\text{s}}$ and has a wavelength of 10. m?

ADVANCED PLACEMENT PHYSICS 1 EQUATIONS, EFFECTIVE 2015

CONSTANTS AND CONVERSION FACTORS			
Proton mass,	$m_p = 1.67 \times 10^{-27}$ kg	Electron charge magnitude,	$e = 1.60 \times 10^{-19}$ C
Neutron mass,	$m_n = 1.67 \times 10^{-27}$ kg	Coulomb's law constant,	$k = 1/4\pi\varepsilon_0 = 9.0 \times 10^9\ \mathrm{N \cdot m^2/C^2}$
Electron mass,	$m_e = 9.11 \times 10^{-31}$ kg	Universal gravitational constant,	$G = 6.67 \times 10^{-11}\ \mathrm{m^3/kg \cdot s^2}$
Speed of light,	$c = 3.00 \times 10^8$ m/s	Acceleration due to gravity at Earth's surface,	$g = 9.8\ \mathrm{m/s^2}$

UNIT SYMBOLS								
	meter,	m	kelvin,	K	watt,	W	degree Celsius,	°C
	kilogram,	k	hertz,	Hz	coulomb,	C		
	second,	s	newton,	N	volt,	V		
	ampere,	A	joule,	J	ohm,	Ω		

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

VALUES OF TRIGONOMETRIC FUNCTIONS FOR COMMON ANGLES							
θ	0°	30°	37°	45°	53°	60°	90°
sin θ	0	1/2	3/5	$\sqrt{2}/2$	4/5	$\sqrt{3}/2$	1
cos θ	1	$\sqrt{3}/2$	4/5	$\sqrt{2}/2$	3/5	1/2	0
tan θ	0	$\sqrt{3}/3$	3/4	1	4/3	$\sqrt{3}$	∞

The following conventions are used in this exam.

I. The frame of reference of any problem is assumed to be inertial unless otherwise stated.
II. Assume air resistance is negligible unless otherwise stated.
III. In all situations, positive work is defined as work done on a system.
IV. The direction of current is conventional current: the direction in which positive charge would drift.
V. Assume all batteries and meters are ideal unless otherwise stated.

ADVANCED PLACEMENT PHYSICS 1 EQUATIONS, EFFECTIVE 2015

MECHANICS

$v_x = v_{xo} + a_x t$

$x = x_o + v_{xo}t + \frac{1}{2}a_x t^2$

$v_x^2 = v_{xo}^2 + 2a_x(x - x_o)$

$\vec{a} = \frac{\sum \vec{F}}{m} = \frac{\vec{F}_{net}}{m}$

$\left|\vec{F}_f\right| \le \mu \left|\vec{F}_n\right|$

$a_c = \frac{v^2}{r}$

$\vec{p} = m\vec{v}$

$\Delta\vec{p} = \vec{F}\Delta t$

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

$\Delta E = W = F_{||}d = Fd\cos\theta$

$P = \frac{\Delta E}{\Delta t}$

$\theta = \theta_o + \omega_o t + \frac{1}{2}\alpha t^2$

$\omega = \omega_o + \alpha t$

$x = A\cos(2\pi ft)$

$\vec{\alpha} = \frac{\sum \vec{\tau}}{I} = \frac{\vec{\tau}_{net}}{I}$

$\tau = r_\perp F = rF\sin\theta$

$L = I\omega$

$\Delta L = \tau\Delta t$

$\left|\vec{F}_s\right| = k\left|\vec{x}\right|$

$U_s = \frac{1}{2}kx^2$

$\rho = \frac{m}{V}$

$U_g = G\frac{m_1 m_2}{r}$

$\Delta U_g = mg\Delta y$

$T = \frac{2\pi}{\omega} = \frac{1}{f}$

$T_s = 2\pi\sqrt{\frac{m}{k}}$

$T_p = 2\pi\sqrt{\frac{\ell}{g}}$

$\left|\vec{F}_g\right| = G\frac{m_1 m_2}{r^2}$

$\vec{g} = \frac{\vec{F}_g}{m}$

a = acceleration
A = amplitude
d = distance
E = energy
f = frequency
F = force
I = rotational inertia
K = kinetic energy
k = spring constant
L = angular momentum
ℓ = length
m = mass
P = power
p = momentum
r = radius or separation
T = period
t = time
U = potential energy
V = volume
v = speed
W = work done on a system
x = position
y = height
α = angular acceleration
μ = coefficient of friction
θ = angle
ρ = density
τ = torque
ω = angular speed

ELECTRICITY

$\left|\vec{F}_E\right| = k\left|\frac{q_1 q_2}{r^2}\right|$

$I = \frac{\Delta q}{\Delta t}$

$R = \frac{\rho\ell}{A}$

$I = \frac{\Delta V}{R}$

$P = I\Delta V$

$R_s = \sum_i R_i$

$\frac{1}{R_p} = \sum_i \frac{1}{R_i}$

A = area
F = force
I = current
ℓ = length
P = power
q = charge
R = resistance
r = separation
t = time
V = electric potential
ρ = resistivity

WAVES

$\lambda = \frac{v}{f}$

f = frequency
v = speed
λ = wavelength

GEOMETRY AND TRIGONOMETRY

Rectangle
$A = bh$

Triangle
$A = \frac{1}{2}bh$

Circle
$A = \pi r^2$
$C = 2\pi r$

Rectangular solid
$V = \ell wh$

Cylinder
$V = \pi r^2\ell$
$S = 2\pi r\ell + 2\pi r^2$

Sphere
$V = \frac{4}{3}\pi r^3$
$S = 4\pi r^2$

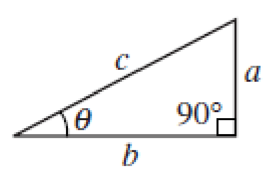
A = area
C = circumference
V = volume
S = surface area
b = base
h = height
ℓ = length
w = width
r = radius

Right triangle
$c^2 = a^2 + b^2$

$\sin\theta = \frac{a}{c}$

$\cos\theta = \frac{b}{c}$

$\tan\theta = \frac{a}{b}$



Summer Assignment Part 2: Multi-Step Problems

The most difficult task in AP Physics 1 is understanding, setting up, and solving multi-step situation (word) problems. As a way of learning to do this, part 2 of your summer assignment is to go through the process in reverse. You must invent a complex situation problem that requires at least three conceptual steps and provide a detailed solution. A suggested approach is:

1. Start with a situation problem, of the type you would find in a typical algebra 1 class. Write down the equation. (Let's call this Equation #1.)
2. Invent a second problem that you need to solve in order to get the value of one of the variables needed for Equation #1. (Let's call the equation for this problem Equation #2.
3. Invent a third problem that you need to solve in order to get one of the variables needed for Equation #2. (Let's call the equation for this problem Equation #3.)
4. Determine all of the variables that you need to specify the values of in order to be able to solve Equation #3, then Equation #2, and then finally Equation #1.
5. Write a single situation problem that describes the situation and gives all of the variables needed (but no additional information).
6. Write out a complete solution:
    a. Start by writing down Equation #3 as all variables (no numbers). Rearrange this equation to solve for the variable needed in Equation #2.
    b. Write down Equation #2 as all variables (again, no numbers). Substitute your expression from part (a) into Equation #2, and rearrange it to solve for the variable needed in Equation #1.
    c. Write down Equation #1 as all variables (no numbers). Substitute your expression from part (b) into Equation #1, and rearrange it to solve for the variable needed to answer the question.
    d. Substitute numbers from the problem into your expression and solve it.

Summer Assignment Part 3: Experiment

The laboratory assignment is to build, trouble-shoot and optimize a device that can time an interval of exactly ten seconds, using whatever materials you can find around your house.

You will bring your timer into school, where you will compete against your classmates to see whose timer comes closest to exactly ten seconds. (The winner in each class gets one "up quark" of extra credit.) You will also be required to turn in a handwritten lab report describing the design, building, and operation of your timer.

The requirements for the timer contest are:

1. Your timer may not use electricity or any kind of clock.
2. Your timer must perform a minimum of *two separate and distinct actions*. For example, a marble that rolls down a ramp and pushes a lever, which rings a bell would count as two distinct actions:
    a. Marble rolls down ramp and hits lever.
    b. Lever swings and hits bell.
3. Your timer may not be an unmodified "off-the-shelf" item. If you use a pre-made device or object as part of your timer, you need to modify it in some substantial way that affects how you use it to measure ten seconds. (Email me if you're not sure.)
4. If your timer does something repetitive, you may count a specific number of repetitions. For example, if the final action of your timer is a ball on a string that winds around a pole, you may measure ten seconds by how long it takes the ball to go around the pole some specific number of times.
5. Your timer may not require human interaction after it has started (except for counting repetitions of some action, as described in rule #4 above).
6. You must declare *in advance* how your timer will indicate when ten seconds has elapsed. For example, having a gadget that flops around on the floor randomly while you count in your head "one-Mississippi, two-Mississippi..." is not acceptable.
7. You have a maximum of two (2) minutes to set up your timer.
8. Students may help each other, but each student must have his/her own timer and write-up.
9. Elapsed time will be measured by Mr. Bigler, using a hand-held stopwatch. Because of the limits of human reaction time, results within 0.1 s of each other will be considered equivalent. (This may result in multiple winners.)

Your write-up should include the following sections:

- **Title & Objective**: a descriptive title and the objective (purpose) of the experiment.
- **Background**: your experimental objective and your overall approach to meeting it.
- **Procedure**: a detailed description of how you built your timer and how you operate it.
- **Data & Observations**: list the time for each of your trial runs (you need a minimum of eight separate data points), and a description of any adjustments/changes you made after each one.
- **Analysis**: calculations, quantitative and qualitative error analysis, and a conclusion.

Following is an illustrative example of the laboratory write-up format that we will use.

Sample Write-Up

The following is an illustrative example of what a lab write-up might look like. Note that lab write-ups must be handwritten (to make copying more inconvenient).

Name: Stu Dent **Date**: 6/17/15

Lab Partners: Rita Book, Joe King

Title: Determining the Velocity of a Rolling Ball

Objective: to measure the average velocities of a ball rolling down a ramp, starting from different heights.

Your Background needs to describe how you intend to obtain the data that you need in order to meet the objective.

- *If you can measure all quantities directly, describe (in a sentence or two) how you will produce and measure the data.*
- *If you cannot measure a quantity directly, start with a formula that includes it and describe (in a sentence or two) how you will produce and measure each quantity in the formula.*
- *If one or more of the necessary variables in the formula cannot be measured directly, apply additional formulas as above until you can produce and measure each quantity you need.*

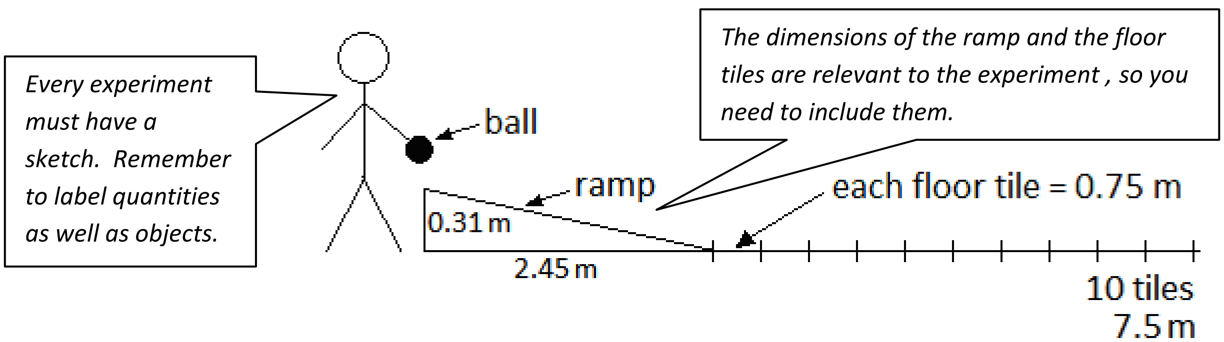
Background: We can't measure $\bar{v}$ directly, so we will solve for it using the formula $\bar{v} = \frac{d}{t}$.

We can measure d and t directly, and from these we can calculate $\bar{v}$.

To measure d and t, roll the ball down a ramp, starting from different positions on the ramp. Mark fixed distance (d) and measure time (t).

Procedure:

1. Measure the width of one tile in the hallway.
2. Count 10 tiles on the floor in the hallway.
3. Place a ramp that is 2.45 m long and 0.31 m high so that the end of the ramp is at the edge of a tile.
4. Mark the start and end point with masking tape.
5. Place the ball at five different points on the ramp and let it roll down the ramp and down the hallway.



6. Record the time it takes the ball to cross the "finish line" (end of the 10th tile past the starting point) for each trial.
7. Calculate the velocity of each trial.

Data & Observations:

Usually the first columns on the left will be your independent variables, then your dependent variables, then your calculated values.

Trial #	Start distance (from end of ramp) (m)	Distance on floor (m)	Time (s)	Average Velocity $\left(\frac{m}{s}\right)$
1	0.5	7.5	4.2	1.79 ± 0.10
2	1.0	7.5	3.7	2.03 ± 0.12
3	1.5	7.5	2.6	2.88 ± 0.17
4	2.0	7.5	2.4	3.13 ± 0.18
5	2.47 (top)	7.5	2.1	3.57 ± 0.21

Analysis:

Discussion:

Discussion should give an overview of the results. The minimum is two sentences for a simple lab, but a complex experiment could require anywhere from a couple of paragraphs to several pages.

The average velocity increased as the point of release of the ball increased.

Calculations:

- *Notice that the formula appears first with variables and then with numbers.*
- *Remember to include the units!*

Sample calculation for average velocity:

$$v = \frac{d}{t}$$

$$v = \frac{7.5\,\text{m}}{4.2\,\text{s}} = 1.79\,\frac{\text{m}}{\text{s}}$$

Uncertainty

Quantitative Uncertainty Calculation

__Note__: average startle response reaction time is 210–220 ms. However, this can be significantly less if the person can anticipate the start and stop events. A reasonable educated guess for a person timing a predictable event with a stopwatch is about 100 ms or 0.1 s.

Assume reaction time is about 0.1 s.

Relative error is $\frac{0.1}{1.79} = 0.0559$

(Equivalent to 5.59% error.)

Estimated error in distance measurement is about 2 mm.

Relative error is $\frac{2}{750} = 0.00267$ (Equivalent to 0.267% error.)

Total relative error is 0.0559 + 0.00267 = 0.0586 (Equivalent to 5.86% error.)

Absolute error is $0.0586 \times 1.79\,\frac{\text{m}}{\text{s}} = \pm 0.10\,\frac{\text{m}}{\text{s}}$.

Detailed results with uncertainties are listed in the data table.

To convert relative error to absolute error, multiply the relative error by the measurement.

Sources of uncertainty:

- Ability to tell exactly when the ball crossed the tape might have varied.
- Ball did not roll in a straight line.

*Sources of uncertainty should **never** include human error unless you think it actually happened and was unavoidable. __**Never**__ say anything that suggests that you or your lab partners might be stupid (such as "We might have written down the wrong number." or "We might have done our calculations wrong.")*

Conclusion:

We calculated the velocities of balls that rolled down a ramp from different heights. The velocities ranged from $1.79 \pm 0.10 \frac{m}{s}$ starting 0.5 m before the end of the ramp to $3.57 \pm 0.21 \frac{m}{s}$ starting from the top of the ramp (2.47 m before the end).

> *Your conclusion needs to restate:*
> 1. *A summary of what you did (one or two sentences).*
> 2. *Your major result(s).*
> 3. *You don't need to repeat sources of uncertainty or errors in your conclusion unless you think they actually had a significant effect on your experiment.*