

## Fall AP Physics 2 Resources

### ADVANCED PLACEMENT PHYSICS 2 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	1 electron volt, $1 \text{ eV} = 1.60 \times 10^{-19}$ J
Electron mass, $m_e = 9.11 \times 10^{-31}$ kg	Speed of light, $c = 3.00 \times 10^8$ m/s
Avogadro's number, $N_0 = 6.02 \times 10^{23}$ mol <sup>-1</sup>	Universal gravitational constant, $G = 6.67 \times 10^{-11}$ m <sup>3</sup> /kg·s <sup>2</sup>
Universal gas constant, $R = 8.31$ J/(mol·K)	Acceleration due to gravity at Earth's surface, $g = 9.8$ m/s <sup>2</sup>
Boltzmann's constant, $k_B = 1.38 \times 10^{-23}$ J/K	
1 unified atomic mass unit,	$1 \text{ u} = 1.66 \times 10^{-27}$ kg = 931 MeV/c <sup>2</sup>
Planck's constant,	$h = 6.63 \times 10^{-34}$ J·s = $4.14 \times 10^{-15}$ eV·s
	$hc = 1.99 \times 10^{-25}$ J·m = $1.24 \times 10^3$ eV·nm
Vacuum permittivity,	$\epsilon_0 = 8.85 \times 10^{-12}$ C <sup>2</sup> /N·m <sup>2</sup>
Coulomb's law constant, $k = 1/4\pi\epsilon_0 = 9.0 \times 10^9$ N·m <sup>2</sup> /C <sup>2</sup>	
Vacuum permeability,	$\mu_0 = 4\pi \times 10^{-7}$ (T·m)/A
Magnetic constant, $k' = \mu_0/4\pi = 1 \times 10^{-7}$ (T·m)/A	
1 atmosphere pressure,	$1 \text{ atm} = 1.0 \times 10^5$ N/m <sup>2</sup> = $1.0 \times 10^5$ Pa

UNIT SYMBOLS	meter, m	mole, mol	watt, W	farad, F
	kilogram, kg	hertz, Hz	coulomb, C	tesla, T
	second, s	newton, N	volt, V	degree Celsius, °C
	ampere, A	pascal, Pa	ohm, Ω	electron volt, eV
	kelvin, K	joule, J	henry, H	

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							
$\theta$	0°	30°	37°	45°	53°	60°	90°
$\sin \theta$	0	1/2	3/5	$\sqrt{2}/2$	4/5	$\sqrt{3}/2$	1
$\cos \theta$	1	$\sqrt{3}/2$	4/5	$\sqrt{2}/2$	3/5	1/2	0
$\tan \theta$	0	$\sqrt{3}/3$	3/4	1	4/3	$\sqrt{3}$	∞

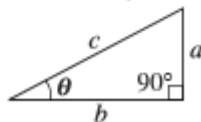
The following conventions are used in this exam.

- I. The frame of reference of any problem is assumed to be inertial unless otherwise stated.
- II. In all situations, positive work is defined as work done on a system.
- III. The direction of current is conventional current: the direction in which positive charge would drift.
- IV. Assume all batteries and meters are ideal unless otherwise stated.
- V. Assume edge effects for the electric field of a parallel plate capacitor unless otherwise stated.
- VI. For any isolated electrically charged object, the electric potential is defined as zero at infinite distance from the charged object.

# ADVANCED PLACEMENT PHYSICS 2 EQUATIONS, EFFECTIVE 2015

MECHANICS		ELECTRICITY AND MAGNETISM	
$v_x = v_{x0} + a_x t$	$a$ = acceleration	$ \vec{F}_E  = \frac{1}{4\pi\epsilon_0} \frac{ q_1 q_2 }{r^2}$	$A$ = area
$x = x_0 + v_{x0} t + \frac{1}{2} a_x t^2$	$A$ = amplitude	$\vec{E} = \frac{\vec{F}_E}{q}$	$B$ = magnetic field
$v_x^2 = v_{x0}^2 + 2a_x(x - x_0)$	$d$ = distance	$ \vec{E}  = \frac{1}{4\pi\epsilon_0} \frac{ q }{r^2}$	$C$ = capacitance
$\vec{a} = \frac{\sum \vec{F}}{m} = \frac{\vec{F}_{net}}{m}$	$E$ = energy	$\Delta U_E = q\Delta V$	$d$ = distance
$ \vec{F}_f  \leq \mu  \vec{F}_n $	$F$ = force	$V = \frac{1}{4\pi\epsilon_0} \frac{q}{r}$	$E$ = electric field
$a_c = \frac{v^2}{r}$	$f$ = frequency	$ \vec{E}  = \left  \frac{\Delta V}{\Delta r} \right $	$\mathcal{E}$ = emf
$\vec{p} = m\vec{v}$	$I$ = rotational inertia	$\Delta V = \frac{Q}{C}$	$F$ = force
$\Delta \vec{p} = \vec{F} \Delta t$	$K$ = kinetic energy	$C = \kappa \epsilon_0 \frac{A}{d}$	$I$ = current
$K = \frac{1}{2} mv^2$	$k$ = spring constant	$E = \frac{Q}{\epsilon_0 A}$	$\ell$ = length
$\Delta E = W = F_{\parallel} d = Fd \cos \theta$	$L$ = angular momentum	$U_C = \frac{1}{2} Q\Delta V = \frac{1}{2} C(\Delta V)^2$	$P$ = power
$P = \frac{\Delta E}{\Delta t}$	$\ell$ = length	$I = \frac{\Delta Q}{\Delta t}$	$Q$ = charge
$\theta = \theta_0 + \omega_0 t + \frac{1}{2} \alpha t^2$	$m$ = mass	$R = \frac{\rho \ell}{A}$	$q$ = point charge
$\omega = \omega_0 + \alpha t$	$P$ = power	$P = I \Delta V$	$R$ = resistance
$x = A \cos(\omega t) = A \cos(2\pi f t)$	$p$ = momentum	$I = \frac{\Delta V}{R}$	$r$ = separation
$x_{cm} = \frac{\sum m_i x_i}{\sum m_i}$	$r$ = radius or separation	$R_s = \sum_i R_i$	$t$ = time
$\vec{\alpha} = \frac{\sum \vec{\tau}}{I} = \frac{\vec{\tau}_{net}}{I}$	$T$ = period	$\frac{1}{R_p} = \sum_i \frac{1}{R_i}$	$U$ = potential (stored) energy
$\tau = r_{\perp} F = r F \sin \theta$	$t$ = time	$C_p = \sum_i C_i$	$V$ = electric potential
$L = I\omega$	$U$ = potential energy	$\frac{1}{C_s} = \sum_i \frac{1}{C_i}$	$v$ = speed
$\Delta L = \tau \Delta t$	$v$ = speed	$B = \frac{\mu_0 I}{2\pi r}$	$\kappa$ = dielectric constant
$K = \frac{1}{2} I\omega^2$	$W$ = work done on a system		$\rho$ = resistivity
$ \vec{F}_s  = k \vec{x} $	$x$ = position		$\theta$ = angle
	$y$ = height		$\Phi$ = flux
	$\alpha$ = angular acceleration		
	$\mu$ = coefficient of friction		
	$\theta$ = angle		
	$\tau$ = torque		
	$\omega$ = angular speed		
	$U_s = \frac{1}{2} kx^2$		
	$\Delta U_g = mg\Delta y$		
	$T = \frac{2\pi}{\omega} = \frac{1}{f}$		
	$T_s = 2\pi \sqrt{\frac{m}{k}}$		
	$T_p = 2\pi \sqrt{\frac{\ell}{g}}$		
	$ \vec{F}_g  = G \frac{m_1 m_2}{r^2}$		
	$\vec{g} = \frac{\vec{F}_g}{m}$		
	$U_G = -\frac{Gm_1 m_2}{r}$		
		$\vec{F}_M = q\vec{v} \times \vec{B}$	
		$ \vec{F}_M  =  q\vec{v}  \sin \theta  \vec{B} $	
		$\vec{F}_M = I\vec{\ell} \times \vec{B}$	
		$ \vec{F}_M  =  I\vec{\ell}  \sin \theta  \vec{B} $	
		$\Phi_B = \vec{B} \cdot \vec{A}$	
		$\Phi_B =  \vec{B}  \cos \theta  \vec{A} $	
		$\mathcal{E} = -\frac{\Delta \Phi_B}{\Delta t}$	
		$\mathcal{E} = B\ell v$	

# ADVANCED PLACEMENT PHYSICS 2 EQUATIONS, EFFECTIVE 2015

<p><b>FLUID MECHANICS AND THERMAL PHYSICS</b></p> $\rho = \frac{m}{V}$ $P = \frac{F}{A}$ $P = P_0 + \rho gh$ $F_b = \rho Vg$ $A_1 v_1 = A_2 v_2$ $P_1 + \rho gy_1 + \frac{1}{2} \rho v_1^2 = P_2 + \rho gy_2 + \frac{1}{2} \rho v_2^2$ $\frac{Q}{\Delta t} = \frac{kA \Delta T}{L}$ $PV = nRT = Nk_B T$ $K = \frac{3}{2} k_B T$ $W = -P \Delta V$ $\Delta U = Q + W$	<p><b>WAVES AND OPTICS</b></p> $\lambda = \frac{v}{f}$ $n = \frac{c}{v}$ $n_1 \sin \theta_1 = n_2 \sin \theta_2$ $\frac{1}{s_i} + \frac{1}{s_o} = \frac{1}{f}$ $ M  = \left  \frac{h_i}{h_o} \right  = \left  \frac{s_i}{s_o} \right $ $\Delta L = m\lambda$ $d \sin \theta = m\lambda$
<p><b>MODERN PHYSICS</b></p> $E = hf$ $K_{\max} = hf - \phi$ $\lambda = \frac{h}{p}$ $E = mc^2$	<p><b>GEOMETRY AND TRIGONOMETRY</b></p> <p>Rectangle  <math>A = bh</math></p> <p>Triangle  <math>A = \frac{1}{2}bh</math></p> <p>Circle  <math>A = \pi r^2</math>  <math>C = 2\pi r</math></p> <p>Rectangular solid  <math>V = \ell wh</math></p> <p>Cylinder  <math>V = \pi r^2 \ell</math>  <math>S = 2\pi r \ell + 2\pi r^2</math></p> <p>Sphere  <math>V = \frac{4}{3} \pi r^3</math>  <math>S = 4\pi r^2</math></p> <p>Right triangle  <math>c^2 = a^2 + b^2</math>  <math>\sin \theta = \frac{a}{c}</math>  <math>\cos \theta = \frac{b}{c}</math>  <math>\tan \theta = \frac{a}{b}</math></p> 

## **Real World Physics: First Semester Project (50 Points – 10% of your semester's grade)**

Ever seen Wyle E. Coyote defy gravity for a moment after chasing the roadrunner off a cliff? As we all have experienced, gravity doesn't wait, but will pull us down as soon as we step off the ledge.

All students (maximum of three/group) will select one instance in popular entertainment (movies or television) in which "bad physics" is demonstrated. One detail: NO CARTOONS. Cartoons already force us to suspend disbelief; only clips from real-life (or CG) will be accepted.

The students will then report to the class the following:

1. Show the incident's footage from the sample. Please keep the clip to under a minute. If you need to verbally fill in the audience as to what happened leading up to the scene, that's OK. Whether this involves renting the DVD, using Youtube, or whatever, the incidents must be shown. I have a computer that will be able to show the clips. Please no VHS tapes – unless you bring your own tape player.  
To maximize effectiveness, you will need to submit your clip to me before the presentation deadline, whether it's the actual clip that I can store on my computer, or a URL that we can click and access a YouTube video, it must be fast.
2. Explain conceptually where the physics is in error.
3. Explain mathematically where the physics is in error, providing at least one equation that could have helped the directors of the movie to abide by the physical laws of the universe.
4. "Fix" the problem (if fixable), OR propose an alternate scenario to the film. This should take at least two minutes to give a complete rendition of your solution(s).
5. Once groups have given their presentations, other students will evaluate their findings, asking questions to clarify or dissect the presenting groups' work. Presenting groups must defend their physics solutions with supporting arguments as needed.
6. Extra credit will be given for individual students who dress up in formal attire.

Presentations should run between 5 and 8 minutes, and will be given at the end of the week before finals. I will pick randomly from the pool of presenters, but if any students volunteer to go first I will honor that.

Groups must register their movies, and the sections of the movie they've elected to do. There should be no redundancy in presentations this way.

The clip must not have nudity, swear words, or excessive violence. I will preview it to ensure that it meets high school standards of decency.

### **Timeline:**

Project Introduction: after Unit 2.C.

Video clip registration deadline: after Unit 3.A (Late fees apply).

Presentations: after Unit 3.B – immediately before finals week.

Fall Semester Project			
Student(s):			
Video Clip From:	View of Clip (1 Minute Max.)	Clip of Movie Present	/ 10
		Too Long (Over 1 minute)?	-1 -2
Total Time (<8 min.) <u>Start</u> <u>Time:</u> _____  <u>End</u> <u>Time:</u> _____  <u>Total</u> <u>Time:</u> _____ Too Long? -2	Error Explanation	Conceptual Errors:	/ 8
		Mathematical Errors Explained:	/ 4
		Equation Provided	/ 3
		Clip Fixed (At least two minutes):	
Cross Examination	Notes:		/ 10
Extra Credit for Dressing Up (Per Student)		_____	+ 2
Registration Late Fee			-2 -4 -6
Total:			/ 50

## **Unit 0 Resources – Conversions & Vectors Review**

**Table 0.1 – A Few Metric to Imperial Conversions**

1 cm = 0.393 inches	1 inch = 2.54 cm
1 m = 3.28 feet	1 foot = 0.3048 m
1 km = 0.621 statute miles = 0.540 nautical miles	1 statute mile = 1.609 km = 0.869 nautical miles
1 mL = 1 cm <sup>3</sup> = 0.061 inches <sup>3</sup>	
1.0 kg = 2.2 pounds	
2.0	

### **Standard Physics Problem Solving Format**

1. Draw a picture of the situation if possible. Include angles, forces, or other values from the problem that will increase conceptualization.
2. Write down any data provided. Include any that are not stated directly in the problem. For example: if a motion problem states that something is falling to earth, you can assume the acceleration due to gravity is  $9.81 \text{ m/s}^2$ .
3. Make unit conversions before starting the problem. For example, if you are given a temperature in degrees Fahrenheit, but the problem deals with gas laws, you convert to Kelvin.
4. List which unknown(s) you are seeking at the end of the data section.
5. List any equations that you think you will use to solve the problem. Rearrange the equations to isolate your target variable BEFORE inserting any numbers.
6. Solve the problem by plugging in numbers and computing the value, in a manner such that other scientists can follow your work. If you have different areas of computations that tie into the problem, connect them with arrows to show where they go.
7. Draw a box around your answer, and include UNITS! Make sure to abide by significant figure and rounding rules, then ask yourself if your answer makes sense.

## Metric Conversions Resource

Some Metric Prefixes		
Prefix	Symbol	Comparable Size:
Giga	G	1 Gigaunit = 1 billion (1 E 9) units
Mega	M	1 Megaunit = 1 million (1 E 6) unit
Kilo	k	1 kilounit = 1,000 (1 E 3) units
Base Dimension = grams, seconds, meters, liters, moles, etc.		1 base unit = 1 base unit
centi	c	100 centiunits = 1 base unit
milli	m	1,000 (1 E 3) milliunits = 1 base unit
micro	μ	1 million (1 E 6) microunits = 1 base unit
nano	n	1 billion (1 E 9) nanounits = 1 base unit

### Conversion Factor Details

Remember that in a fraction, there is a numerator and a denominator:

$$\frac{\text{Numerator (Top)}}{\text{Denominator (Bottom)}}$$

### Note:

When converting from a large prefixed unit to a small one, the exponent **increases**.

When converting from a small prefixed unit to a large one, the exponent **decreases**.

### Process

1. Write down the value you want to convert with its unit(s)
2. Multiply it by a conversion factor such that the unit you want to end up with is in the numerator, and the one you are converting from is in the denominator.
3. For multiple step conversions, add more conversion factors, so that the undesired units cancel out.
4. Cancel out units, and perform the mathematical steps (multiply numerators, divide by denominators)

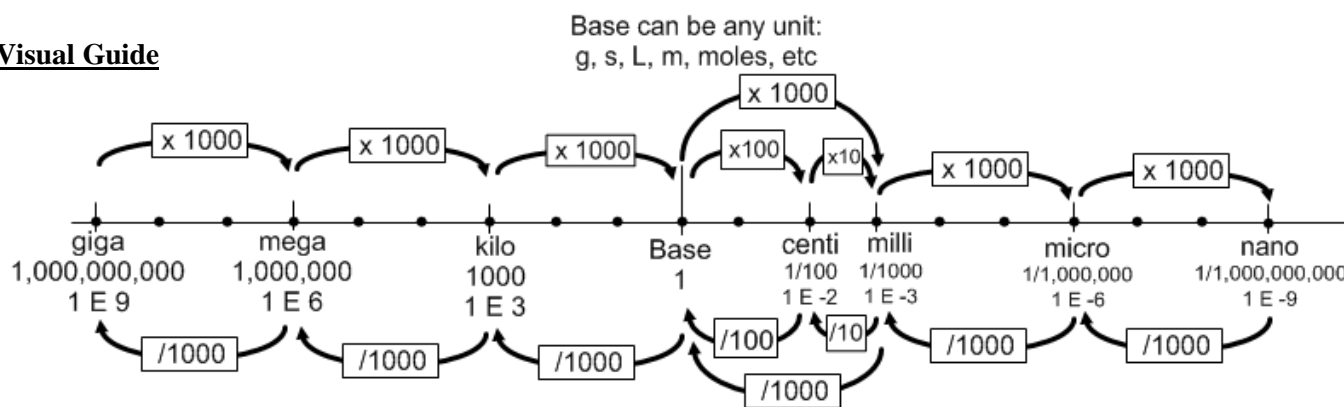
**Example 1:** 145 ng → g

$$145 \text{ ng} \times \frac{1 \text{ g}}{1 \text{ E } 9 \text{ ng}} = 1.45 \text{ E } -7 \text{ g}$$

**Example 2:** 9.40 cm/min → m/s

$$\frac{9.40 \text{ cm}}{1 \text{ min}} \times \frac{1 \text{ m}}{100 \text{ cm}} \times \frac{1 \text{ min}}{60 \text{ s}} = 1.57 \text{ E } -3 \text{ m/s}$$

### Visual Guide



## **Unit 1 Resources – Fluid Mechanics**

<b>1.1 Density Resource</b>					
<b>Substance</b>	<b>Density (kg/m<sup>3</sup>)</b>	<b>Substance</b>	<b>Density (kg/m<sup>3</sup>)</b>	<b>Substance</b>	<b>Density (kg/m<sup>3</sup>)</b>
<b>Solids</b>		<b>Liquids</b>		<b>Gases</b>	
Aluminum	2700	Alcohol, ethyl	790	Air	1.29
Brass	8700	Alcohol, methyl	820	Helium	0.18
Copper	8900	Blood, whole	1050	Hydrogen	0.090
Glass	2600	Blood plasma	1030	Oxygen	1.43
Gold	19,300	Gasoline	680	Water Vapor	0.63
Ice	920	Kerosene	820		
Iron and Steel	7800	Mercury	13,600		
Lead	11,400	Seawater (4°C)	1030		
Silver	10,500	Water, fresh (4°C)	1000		
Wood, oak	810				

## **Unit 2 Resources – Kinetic Theory, Heat, Thermodynamics**

<b>2.A Thermal Expansion Coefficients Resource</b>			
<b>Material</b>	<b>Coefficient of Linear Expansion (<math>\alpha</math>) (/°C)</b>	<b>Material</b>	<b>Coefficient of Volume Expansion (<math>\beta</math>) (/°C)</b>
Aluminum	24 E -6	Ethyl Alcohol	1.1 E -4
Brass	19 E -6	Gasoline	9.5 E -4
Brick & Concrete	12 E -6	Glycerin	4.9 E -4
Copper	17 E -6	Mercury	1.8 E -4
Window Glass	9.0 E -6	Water	2.1 E -4
Pyrex Glass	3.3 E -6	Air, and most other gases at 1.0 atm	3.5 E -3
Gold	14 E -6		
Ice	52 E -6		
Iron & Steel	12 E -6		

<b>2.B.1 Specific Heat Constants Resource</b>					
<b>Substance</b>	<b>J/(kg•°C)</b>	<b>kcal/(kg•°C)</b>	<b>Substance</b>	<b>J/(kg•°C)</b>	<b>kcal/(kg•°C)</b>
<b>Solids</b>			<b>Liquids</b>		
Aluminum	920	0.220	Ethyl Alcohol	2450	0.585
Copper	390	0.0932	Glycerin	2410	0.576
Glass	840	0.201	Mercury	139	0.0332
Ice	2100	0.500	Water	4186	1.000
Iron/Steel	460	0.110	<b>Gas</b>		
Lead	130	0.0311	Steam	2000	0.48

Soil	1050	0.251	
Wood	1680	0.401	
Human Body	3500	0.84	

## 2.B.2 Temperatures of Phase Changes and Latent Heats Resource

$L_f$				$L_v$		
Substance	Melting Point	J/kg	kcal/kg	Boiling Point	J/kg	kcal/kg
Alcohol	-114 °C	1.0 E 5	25	78 °C	8.5 E 5	204
Gold	1063 °C	0.645 E 5	15.4	2660 °C	15.8 E 5	377
Helium	---	---	---	-269 °C	0.21 E 5	5
Lead	328 °C	0.25 E 5	5.9	1744 °C	8.67 E 5	207
Mercury	-39 °C	0.12 E 5	2.8	357 °C	2.7 E 5	65
Nitrogen	-210 °C	0.26 E 5	6.1	-196 °C	2.0 E 5	48
Oxygen	-219 °C	0.14 E 5	3.3	-183 °C	2.1 E 5	51
Tungsten	3410 °C	1.80 E 5	44	5900 °C	48.2 E 5	1150
Water/Ice	0.0 °C	3.33 E 5	80	100 °C	22.6 E 5	540

## 2.B.3 Thermal Conductivities (k) Resource

Substance	J/(m•s•°C)	Kcal/(m•s•°C)	Substance	J/(m•s•°C)	Kcal/(m•s•°C)
Metals			Other Materials		
Aluminum	240	5.73 E -2	Brick	0.71	17 E -5
Copper	390	9.32 E -2	Concrete	1.3	31 E -5
Iron	80	1.9 E -2	Cotton	0.075	1.8 E -5
Stainless Steel	16	3.8 E -3	Fiberboard	0.059	1.4 E -5
Silver	420	10 E -2	Floor Tile	0.67	16 E -5
Liquids			Glass	0.84	20 E -5
Transformer Oil	0.18	4.3 E -5	Glass Wool	0.042	1.0 E -5
Water	0.57	14 E -5	Goose Down	0.025	0.59 E -5
Gases			Human Tissue	0.2	4.8 E -5
Air	0.024	0.57 E -5	Ice	2.2	53 E -5
Hydrogen	0.17	4.1 E -5	Styrofoam	0.042	1.0 E -5
Oxygen	0.024	0.57 E -5	Wood, Oak	0.15	3.6 E -5
			Wood, Pine	0.12	2.9 E -5
			Vacuum	0	0

## Unit 3 Resources – Electrical Theory and Basic Circuits

### 3.A Subatomic Particles and Charges Resource

Particle	Electric Charge	Mass
Electron	-1.602 E -19 C	$m_e = 9.109 \text{ E } -31 \text{ kg}$
Proton	+1.602 E -19 C	$m_p = 1.673 \text{ E } -27 \text{ kg}$
Neutron	0	$m_n = 1.675 \text{ E } -27 \text{ kg}$

### 3.B Dielectric Constants ( $\kappa$ ) of Materials Resource

Material	Constant ( $\kappa$ )	Material	Constant ( $\kappa$ )	Material	Constant ( $\kappa$ )
Vacuum	1.0000	Polystyrene	2.6	Bakelite	4.9



Air	1.00059	Teflon	2.1	Silicon Oil	2.6
Paper	3.7	Glass (Range)	3 – 7	Water	80
Polyethylene	2.3	Pyrex Glass	5.6	Strontium Titanate	233

## Excel Tutorial Resource

This resource will allow you to use the spreadsheet program Microsoft Excel at a rudimentary level, and produce graphs. My hope is that you can eventually use this to make world-class lab reports.

### Basic Functions in Excel:

Excel, as a spreadsheet program, has great capacity to manipulate numbers. Here are some common ones.

Basic Math Functions	
Addition	+
Subtraction	-
Division	/
Multiplication	*
Square Root	^.5
Square	^2

### Making Equations in Excel:

To program equations in excel, start by inputting an equal sign (=) in your cell. Then, fill in your equation, using the functions listed in the table above.

Often, you will want to manipulate values of different cells against each other. Since each cell has a designation (letter/number (Ex: C5)), you can program equations with different cells by selecting the cells as you enter your equation.

Example:

	A	B	C
1	Grams	mL	Density
2	13.4	9.8	=A2/B2

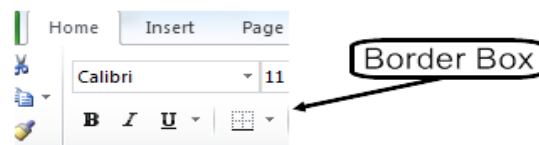
The output for C2 will be 1.3673469 as soon as I press Enter.

### Miscellaneous Useful Functions:

Some time-saving, or tidying functions in Excel, besides cutting (Ctrl-x), copying (Ctrl-c), and pasting (Ctrl-v) are:

Copying a formula: Select the parent cell you want to copy, then click and drag the little black square at the bottom right of the cell. When you release, your formula will have been copied to all the destination cells.

Borders: It puts a nice finish on your data set when it's bounded by a thoughtful border. There are lots of choices, select the data you want to border, and click on the one that works for you.



Widening/Shrinking Columns/Rows: Hover over the junction between letters or numbers at the top or side of your spreadsheet, and a line with a double headed arrow will appear. Click and hold while moving the cursor where you want it. You will see the number of pixels that the column or row is.

Wrapping Text: Sometimes it will make sense to make your text go on two or more lines. Select the cell(s) you want to do this to, then right click. Choose the "format cells" option. Click the 'Alignment' tab, then click the little box that says 'Wrap Text'.

13	Yay?	This sentence is too long	Yay?
----	------	---------------------------	------

Before:

12				
13	Yay?	ntence is t	Yay?	

After:

**Merging Cells:** You may need to engineer a spreadsheet so that two or more cells are combined into one. This could happen if you have a long title for a data table and want it to always be visible. Select the cells you want to do this to, then right click. Choose the “format cells” option. Click the ‘Alignment’ tab, then click the little box that says ‘Merge Cells’.

**Subscript/Superscripting:** Select the bit of text you want to do this to, then right click. Choose the “format cells” option. Click the little box that says ‘Superscript’ or ‘Subscript’.

**Holding a value in a copied formula:** Once in a while, you’ll copy a formula with a fixed value you want to keep the same from cell to cell. Putting dollar signs in front of the cell’s letter/number values will achieve this.

Example:

	A	B	C
1	Acceleration	Time (s)	Velocity
2	9.81	0.00	=A\$2*B2
3	This is the	0.50	
4	fixed value,	1.00	
5	as I copy the	1.50	
6	formula it	2.00	
7	must not	2.50	
8	change.	3.00	

After copying:

	A	B	C
1	Acceleration	Time (s)	Velocity
2	9.81	0.00	0
3		0.50	4.905
4		1.00	9.81
5		1.50	14.715
6		2.00	19.62
7		2.50	24.525
8		3.00	29.43

## Graphing in Excel

In this class, you will most likely want to make x-y scatter plots to pit one value against another. This is a simple procedure to make a basic, no-frills graph:

1. Select the exact data that you want to graph. If the two columns are separated, first select one of the columns, then hold down the Control key while selecting the second column.
2. Press the Insert tab at the top of the Excel worksheet, and select ‘scatter.’ Several types are available: I recommend the one with points and smooth curves.
3. Unless you have more than one series, delete the ‘Series 1’ at the right of your graph.
4. **Titles.** When your chart is selected, a ‘Chart Tools’ tab opens up with three sub-tabs: Design, Layout, and Format. Select the ‘Layout’ tab, then click on ‘Chart Title’. Give your chart a title that describes what you’re graphing.
5. Click ‘Axis Titles’ and give your graph both horizontal, and vertical titles (with units!) The options for the vertical axis are several – choose the one that is the most useful.
6. To print your graph, select the graph and press Control-P. If you want to include your graph along with your spreadsheet data, select the spreadsheet and press Control-P.

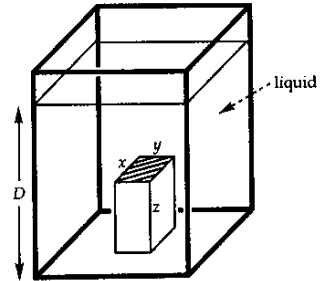
There are always more ways to improve your graph, take some time to add details to it if you choose. I may have some ideas as to how to do specific things, just ask.

### Wizard Challenges by Unit

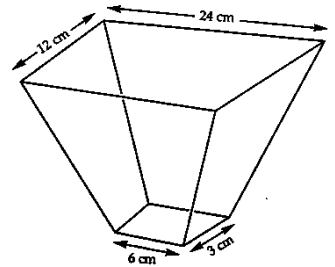
These problems are more advanced than those in the regular homework section, and successfully completing them will earn you two points per problem, applied to the Assessments category of your grade.

#### Unit 1.

1. (Section 1.1) In the figure, a box of dimensions  $x$ ,  $y$ , and  $z$  rests on the bottom of a tank filled to depth  $D$  with a liquid of density  $\rho$ . If the tank is open to the atmosphere, what is the force on the (shaded) top of the box?



2. (Section 1.4) This figure shows a portion of a conduit for water, one with rectangular cross sections. If the flow speed at the top is  $v$ , what is the flow speed at the bottom?



3. (Section 1.5) A pump is used to send water through a hose, the diameter of which is 10 times that of the nozzle through which the water exits. If the nozzle is 1 m higher than the pump, and the water flows through the hose at 0.4 m/s, what is the gauge pressure of the water at the pump?

#### Unit 3.A

1. Two charges,  $-3.0\text{ C}$  and  $-4.0\text{ C}$ , are located at  $(-0.5\text{ m}, 0\text{ m})$ , and  $(0.5\text{ m}, 0\text{ m})$ , respectively. Find the point on the  $x$ -axis between the two charges where the electric field is zero.

<b>Fall Review Points: / 15</b>
<b>Late/Inc. Fee: -1 -2 -3</b>

## **AP Physics 2 Fall Semester Review Questions**

This is an opportunity to see how much you know or remember about what we've covered so far in Physics. Select at least 15 of the following math-based questions and answer them for credit. I will check for your effort and then provide a solution set. You may use this on the final.

### **Unit 1: Solids and Fluids**

1. If you dive to a depth of 5.0 m below the surface of a mercury lake, what is the gauge pressure?
  
2. A hydraulic lift has an input piston area of  $13.5 \text{ cm}^2$ , and an output piston area of  $256 \text{ cm}^2$ . How much force would have to be exerted on the input piston to lift a 750 kg car?
  
3. A glass cube 0.25 m on each side is suspended from a scale and immersed in water. What will the scale read? Assume a density of  $2.6 \times 10^3 \text{ kg/m}^3$ .
  
4. If the radius of a pipe increases to four times its original size, what is the ratio of the flow speed in the wider section to that in the narrower section?
  
5. Water flowing through a wide horizontal tube is constricted to half the diameter. If the water speed is 2.3 m/s in the larger part of the tube, by how much does the pressure drop in the constricted part?
  
6. Water flowing through a pipe of radius 3.5 cm travels from a pump that exerts a pressure of 1500 Pa at ground level up to a 1.5 cm radius faucet in a bathroom 14 m above the pump. If the water speed at the pump is 2.8 cm/s, what's the speed coming out of the nozzle? How long would it take to fill a 1.0 L pitcher?

### **Unit 2.A: Temperature and Kinetic Theory**

1.  $2.8 \text{ m}^3$  of a monatomic gas at room temperature (300K) and atmospheric pressure (101 kPa) is compressed into a volume of  $0.25 \text{ m}^3$  and held at a temperature of 255 K. What is the pressure of the compressed gas?
2. Gas in a 2.4 L piston increases in pressure by 2.5 times. By what factor did the volume change?
3. A steel disc has a diameter of 9.4 cm at  $40^\circ\text{C}$ . If it is heated to  $250^\circ\text{C}$ , what will be the resulting diameter?
4. The average kinetic energy per molecule of a monatomic gas is  $1.0 \text{ E } -21 \text{ J}$ , what is the Celsius temperature of the gas?
5. If 2.5 mol of a diatomic gas has a total internal energy of  $3.4 \text{ E } 4 \text{ J}$  at a certain temperature, what is the total internal energy of 2.5 mol of a monatomic gas at that same temperature?

### **Unit 2.B: Heat**

1. A 220 gram mystery material loses 28,400 J of heat during a process where it goes from 480 °C to 150 °C. What is the specific heat of the material, and what could the material be?
2. A 250.0 g pellet of copper reaches a final temperature of 130.0 °C when gaining 2,200. J of heat. What was its initial temperature?
3. An artist wants to melt some glass to make a very delicate statue. How much heat would have to be added to 1.5 kg of glass starting at 20 °C to cause it to melt completely at a temperature of 1400 °C, then reach a good pouring temperature of 1700 °C? The  $L_f$  of glass is about  $0.35 \times 10^5$  J/kg, and its specific heat as a liquid is about 2100 J/K•°C.
4. If a heated aluminum block in empty space radiates 150 watts at 350 °C with an emissivity of 0.25, what is the area of the block?

### **Unit 2.C: Thermodynamics**

1. An ideal gas is under an initial pressure of  $3.4 \times 10^4$  Pa and occupies a volume of  $0.50 \text{ m}^3$ . The addition of  $5.3 \times 10^4$  J of heat to this gas causes it to expand isobarically to a volume of  $0.90 \text{ m}^3$ . How much work is done by the gas in the process?
2. A quantity of ideal gas goes through an isothermal process and does 500.0 J of net work. Is a net amount of heat added or removed from the system, and how much is involved?
3. What is the change in entropy of mercury vapor ( $L_v = 2.7 \times 10^5$  J/kg) when 1.30 kg of it condenses to a liquid at its boiling point of  $357^\circ\text{C}$ ?
4. In an isothermal expansion at  $130.0^\circ\text{C}$ , an ideal gas does 610.0 J of work. What is the change in entropy of the gas?
5. A steam engine operates between  $105^\circ\text{C}$  and  $20.0^\circ\text{C}$ . What is the Carnot efficiency of the ideal engine that operates between these temperatures?

### **Unit 3.A: Electric Charge, Forces, Fields**

1. What is the electric force between two opposite charges (charge A and B) of  $1.5\ \mu\text{C}$  each, separated by a distance of 55 cm? If charge A has a mass of 1.3 g, what is its initial acceleration if released from rest? Will the acceleration increase or decrease as time goes by?
2. If the original electric field due to a charge is  $1.0 \times 10^{-14}\ \text{N/C}$ , what is the magnitude of the new electric field at twice the distance from the charge?
3. At what distance from a group of three protons is the electric field magnitude  $2.3 \times 10^2\ \text{N/C}$ ?
4. Three conducting spheres of identical size are hovering in space. The first is given a charge of  $-5Q$ , then touched to the second. When those are separated, the second touches the third. Next, they are separated, the second one is put aside and the first touches the third. After separation, what is the resulting charge on each sphere?
5. If the force between two identical  $+4.2\ \text{mC}$  charges is 13.2 N, how far apart are the charges?
6. What is the force on a  $13\ \text{nC}$  charge in a  $19.5\ \text{N/C}$  electric field? If it's got a mass of 1.2 mg, what will its acceleration be?

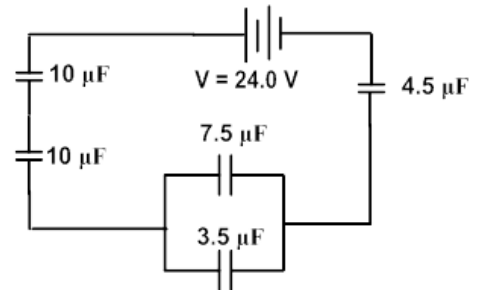


### **Unit 3.B: Electric Potential and Capacitance**

1. A pair of parallel plates is charged by a 24-V battery. If the electric field between the plates is 130 N/C, how far apart are the plates?
2. How far from a  $+2.3 \mu\text{C}$  charge is a point with an electric potential of 150 V?
3. A 24.0 V battery is connected to a parallel plate capacitor with a plate area of  $0.324 \text{ m}^2$  and a plate separation of 1.4 mm. What is the charge on the capacitor? How much energy is stored in the capacitor?
4. A parallel plate capacitor has a capacitance of  $1.5 \mu\text{F}$  with air between the plates. The capacitor is connected to a 12 V battery and charged. The battery is then removed. When a dielectric is placed between the plates, a potential difference of 5.0 V is measured across the plates. What is the dielectric constant of the material?

Analyze the following capacitor circuit:

5. What is the equivalent capacitance?
6. What is the energy storage of the circuit?



The Periodic Table of the Elements

1																		2																	
H Hydrogen 1.00794																				He Helium 4.003															
3		4																		9		10													
Li Lithium 6.941		Be Beryllium 9.012182																		F Fluorine 18.9984032		Ne Neon 20.1797													
11		12																		17		18													
Na Sodium 22.989770		Mg Magnesium 24.3050																		S Sulfur 32.066		Ar Argon 39.948													
19		20		21		22		23		24		25		26		27		28		29		30		31		32		33		34		35		36	
K Potassium 39.0983		Ca Calcium 40.078		Sc Scandium 44.955910		Ti Titanium 47.867		V Vanadium 50.9415		Cr Chromium 51.9961		Mn Manganese 54.938049		Fe Iron 55.845		Co Cobalt 58.933200		Ni Nickel 58.6934		Cu Copper 63.546		Zn Zinc 65.39		Ga Gallium 69.723		Ge Germanium 72.61		As Arsenic 74.92160		Se Selenium 78.96		Br Bromine 79.904		Kr Krypton 83.80	
37		38		39		40		41		42		43		44		45		46		47		48		49		50		51		52		53		54	
Rb Rubidium 85.4678		Sr Strontium 87.62		Y Yttrium 88.90585		Zr Zirconium 91.224		Nb Niobium 92.90638		Mo Molybdenum 95.94		Tc Technetium (98)		Ru Ruthenium 101.07		Rh Rhodium 102.90550		Pd Palladium 106.42		Ag Silver 107.8682		Cd Cadmium 112.411		In Indium 114.818		Sn Tin 118.710		Sb Antimony 121.760		Te Tellurium 127.60		I Iodine 126.90447		Xe Xenon 131.29	
55		56		57		72		73		74		75		76		77		78		79		80		81		82		83		84		85		86	
Cs Cesium 132.90545		Ba Barium 137.327		La Lanthanum 138.9055		Hf Hafnium 178.49		Ta Tantalum 180.9479		W Tungsten 183.84		Re Rhenium 186.207		Os Osmium 190.23		Ir Iridium 192.217		Pt Platinum 195.078		Au Gold 196.96655		Hg Mercury 200.59		Tl Thallium 204.3833		Pb Lead 207.2		Bi Bismuth 208.98038		Po Polonium (209)		At Astatine (210)		Rn Radon (222)	
87		88		89		104		105		106		107		108		109		110		111		112		113		114									
Fr Francium (223)		Ra Radium (226)		Ac Actinium (227)		Rf Rutherfordium (261)		Db Dubnium (262)		Sg Seaborgium (263)		Bh Bohrium (262)		Hs Hassium (265)		Mt Meitnerium (266)				(272)		(277)													

## Fall AP Physics 2 Resources to use on ALL Semester 1 Tests

### ADVANCED PLACEMENT PHYSICS 2 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	1 electron volt, $1 \text{ eV} = 1.60 \times 10^{-19}$ J
Electron mass, $m_e = 9.11 \times 10^{-31}$ kg	Speed of light, $c = 3.00 \times 10^8$ m/s
Avogadro's number, $N_0 = 6.02 \times 10^{23}$ mol <sup>-1</sup>	Universal gravitational constant, $G = 6.67 \times 10^{-11}$ m <sup>3</sup> /kg·s <sup>2</sup>
Universal gas constant, $R = 8.31$ J/(mol·K)	Acceleration due to gravity at Earth's surface, $g = 9.8$ m/s <sup>2</sup>
Boltzmann's constant, $k_B = 1.38 \times 10^{-23}$ J/K	
1 unified atomic mass unit, $1 \text{ u} = 1.66 \times 10^{-27}$ kg = 931 MeV/c <sup>2</sup>	
Planck's constant, $h = 6.63 \times 10^{-34}$ J·s = $4.14 \times 10^{-15}$ eV·s	
	$hc = 1.99 \times 10^{-25}$ J·m = $1.24 \times 10^3$ eV·nm
Vacuum permittivity, $\epsilon_0 = 8.85 \times 10^{-12}$ C <sup>2</sup> /N·m <sup>2</sup>	
Coulomb's law constant, $k = 1/4\pi\epsilon_0 = 9.0 \times 10^9$ N·m <sup>2</sup> /C <sup>2</sup>	
Vacuum permeability, $\mu_0 = 4\pi \times 10^{-7}$ (T·m)/A	
Magnetic constant, $k' = \mu_0/4\pi = 1 \times 10^{-7}$ (T·m)/A	
1 atmosphere pressure, $1 \text{ atm} = 1.0 \times 10^5$ N/m <sup>2</sup> = $1.0 \times 10^5$ Pa	

UNIT SYMBOLS	meter, m	mole, mol	watt, W	farad, F
	kilogram, kg	hertz, Hz	coulomb, C	tesla, T
	second, s	newton, N	volt, V	degree Celsius, °C
	ampere, A	pascal, Pa	ohm, Ω	electron volt, eV
	kelvin, K	joule, J	henry, H	

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							
$\theta$	0°	30°	37°	45°	53°	60°	90°
$\sin \theta$	0	1/2	3/5	$\sqrt{2}/2$	4/5	$\sqrt{3}/2$	1
$\cos \theta$	1	$\sqrt{3}/2$	4/5	$\sqrt{2}/2$	3/5	1/2	0
$\tan \theta$	0	$\sqrt{3}/3$	3/4	1	4/3	$\sqrt{3}$	∞

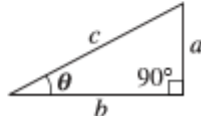
The following conventions are used in this exam.

- I. The frame of reference of any problem is assumed to be inertial unless otherwise stated.
- II. In all situations, positive work is defined as work done on a system.
- III. The direction of current is conventional current: the direction in which positive charge would drift.
- IV. Assume all batteries and meters are ideal unless otherwise stated.
- V. Assume edge effects for the electric field of a parallel plate capacitor unless otherwise stated.
- VI. For any isolated electrically charged object, the electric potential is defined as zero at infinite distance from the charged object.

# ADVANCED PLACEMENT PHYSICS 2 EQUATIONS, EFFECTIVE 2015

MECHANICS		ELECTRICITY AND MAGNETISM	
$v_x = v_{x0} + a_x t$	$a$ = acceleration	$ \vec{F}_E  = \frac{1}{4\pi\epsilon_0} \frac{ q_1 q_2 }{r^2}$	$A$ = area
$x = x_0 + v_{x0} t + \frac{1}{2} a_x t^2$	$A$ = amplitude	$\vec{E} = \frac{\vec{F}_E}{q}$	$B$ = magnetic field
$v_x^2 = v_{x0}^2 + 2a_x(x - x_0)$	$d$ = distance	$ \vec{E}  = \frac{1}{4\pi\epsilon_0} \frac{ q }{r^2}$	$C$ = capacitance
$\vec{a} = \frac{\sum \vec{F}}{m} = \frac{\vec{F}_{net}}{m}$	$E$ = energy	$\Delta U_E = q\Delta V$	$d$ = distance
$ \vec{F}_f  \leq \mu  \vec{F}_n $	$F$ = force	$V = \frac{1}{4\pi\epsilon_0} \frac{q}{r}$	$E$ = electric field
$a_c = \frac{v^2}{r}$	$f$ = frequency	$ \vec{E}  = \left  \frac{\Delta V}{\Delta r} \right $	$\mathcal{E}$ = emf
$\vec{p} = m\vec{v}$	$I$ = rotational inertia	$\Delta V = \frac{Q}{C}$	$F$ = force
$\Delta \vec{p} = \vec{F} \Delta t$	$K$ = kinetic energy	$C = \kappa \epsilon_0 \frac{A}{d}$	$I$ = current
$K = \frac{1}{2} mv^2$	$k$ = spring constant	$E = \frac{Q}{\epsilon_0 A}$	$\ell$ = length
$\Delta E = W = F_{\parallel} d = Fd \cos \theta$	$L$ = angular momentum	$U_C = \frac{1}{2} Q\Delta V = \frac{1}{2} C(\Delta V)^2$	$P$ = power
$P = \frac{\Delta E}{\Delta t}$	$\ell$ = length	$I = \frac{\Delta Q}{\Delta t}$	$Q$ = charge
$\theta = \theta_0 + \omega_0 t + \frac{1}{2} \alpha t^2$	$m$ = mass	$R = \frac{\rho \ell}{A}$	$q$ = point charge
$\omega = \omega_0 + \alpha t$	$P$ = power	$P = I \Delta V$	$R$ = resistance
$x = A \cos(\omega t) = A \cos(2\pi f t)$	$p$ = momentum	$I = \frac{\Delta V}{R}$	$r$ = separation
$x_{cm} = \frac{\sum m_i x_i}{\sum m_i}$	$r$ = radius or separation	$R_s = \sum_i R_i$	$t$ = time
$\vec{\alpha} = \frac{\sum \vec{\tau}}{I} = \frac{\vec{\tau}_{net}}{I}$	$T$ = period	$\frac{1}{R_p} = \sum_i \frac{1}{R_i}$	$U$ = potential (stored) energy
$\tau = r_{\perp} F = r F \sin \theta$	$t$ = time	$C_p = \sum_i C_i$	$V$ = electric potential
$L = I\omega$	$U$ = potential energy	$\frac{1}{C_s} = \sum_i \frac{1}{C_i}$	$v$ = speed
$\Delta L = \tau \Delta t$	$v$ = speed	$B = \frac{\mu_0 I}{2\pi r}$	$\kappa$ = dielectric constant
$K = \frac{1}{2} I\omega^2$	$W$ = work done on a system		$\rho$ = resistivity
$ \vec{F}_s  = k \vec{x} $	$x$ = position		$\theta$ = angle
	$y$ = height		$\Phi$ = flux
	$\alpha$ = angular acceleration		
	$\mu$ = coefficient of friction		
	$\theta$ = angle		
	$\tau$ = torque		
	$\omega$ = angular speed		
	$U_s = \frac{1}{2} kx^2$		
	$\Delta U_g = mg\Delta y$		
	$T = \frac{2\pi}{\omega} = \frac{1}{f}$		
	$T_s = 2\pi \sqrt{\frac{m}{k}}$		
	$T_p = 2\pi \sqrt{\frac{\ell}{g}}$		
	$ \vec{F}_g  = G \frac{m_1 m_2}{r^2}$		
	$\vec{g} = \frac{\vec{F}_g}{m}$		
	$U_G = -\frac{Gm_1 m_2}{r}$		
		$\vec{F}_M = q\vec{v} \times \vec{B}$	
		$ \vec{F}_M  =  q\vec{v}  \sin \theta  \vec{B} $	
		$\vec{F}_M = I\vec{\ell} \times \vec{B}$	
		$ \vec{F}_M  =  I\vec{\ell}  \sin \theta  \vec{B} $	
		$\Phi_B = \vec{B} \cdot \vec{A}$	
		$\Phi_B =  \vec{B}  \cos \theta  \vec{A} $	
		$\mathcal{E} = -\frac{\Delta \Phi_B}{\Delta t}$	
		$\mathcal{E} = B\ell v$	

# ADVANCED PLACEMENT PHYSICS 2 EQUATIONS, EFFECTIVE 2015

<p><b>FLUID MECHANICS AND THERMAL PHYSICS</b></p> $\rho = \frac{m}{V}$ $P = \frac{F}{A}$ $P = P_0 + \rho gh$ $F_b = \rho Vg$ $A_1 v_1 = A_2 v_2$ $P_1 + \rho gy_1 + \frac{1}{2} \rho v_1^2 = P_2 + \rho gy_2 + \frac{1}{2} \rho v_2^2$ $\frac{Q}{\Delta t} = \frac{kA \Delta T}{L}$ $PV = nRT = Nk_B T$ $K = \frac{3}{2} k_B T$ $W = -P \Delta V$ $\Delta U = Q + W$	<p><b>WAVES AND OPTICS</b></p> $\lambda = \frac{v}{f}$ $n = \frac{c}{v}$ $n_1 \sin \theta_1 = n_2 \sin \theta_2$ $\frac{1}{s_i} + \frac{1}{s_o} = \frac{1}{f}$ $ M  = \left  \frac{h_i}{h_o} \right  = \left  \frac{s_i}{s_o} \right $ $\Delta L = m\lambda$ $d \sin \theta = m\lambda$ <p><i>d</i> = separation  <i>f</i> = frequency or focal length  <i>h</i> = height  <i>L</i> = distance  <i>M</i> = magnification  <i>m</i> = an integer  <i>n</i> = index of refraction  <i>s</i> = distance  <i>v</i> = speed  <math>\lambda</math> = wavelength  <math>\theta</math> = angle</p>
<p><b>MODERN PHYSICS</b></p> $E = hf$ $K_{\max} = hf - \phi$ $\lambda = \frac{h}{p}$ $E = mc^2$ <p><i>E</i> = energy  <i>f</i> = frequency  <i>K</i> = kinetic energy  <i>m</i> = mass  <i>p</i> = momentum  <math>\lambda</math> = wavelength  <math>\phi</math> = work function</p>	<p><b>GEOMETRY AND TRIGONOMETRY</b></p> <p>Rectangle  <math>A = bh</math>  <i>A</i> = area  <i>C</i> = circumference  <i>V</i> = volume</p> <p>Triangle  <math>A = \frac{1}{2}bh</math>  <i>S</i> = surface area  <i>b</i> = base  <i>h</i> = height  <math>\ell</math> = length</p> <p>Circle  <math>A = \pi r^2</math>  <math>C = 2\pi r</math>  <i>w</i> = width  <i>r</i> = radius</p> <p>Rectangular solid  <math>V = \ell wh</math></p> <p>Cylinder  <math>V = \pi r^2 \ell</math>  <math>S = 2\pi r \ell + 2\pi r^2</math></p> <p>Sphere  <math>V = \frac{4}{3} \pi r^3</math>  <math>S = 4\pi r^2</math></p> <p>Right triangle  <math>c^2 = a^2 + b^2</math>  <math>\sin \theta = \frac{a}{c}</math>  <math>\cos \theta = \frac{b}{c}</math>  <math>\tan \theta = \frac{a}{b}</math></p> 

**AP Physics 2 Student Notes: Allowed on ALL Semester 1 Tests**

Unit 1: Fluid Mechanics Notes

Unit 2.A: Temperature and Kinetic Theory Notes

Unit 2.B: Heat Notes

Unit 2.C: Thermodynamics Notes

Unit 3.A: Electric Charge, Forces, Fields Notes

Unit 3.B: Electric Potential and Capacitance Notes

