ADVANCED PLACEMENT PHYSICS 2 TABLE OF INFORMATION

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, $N_0 = 6.02 \; x \; 10^{23} \text{mol}^{-1}$	Universal gravitational constant, $G = 6.67 \times 10^{-11}$ m³/kg•s²
Universal gas constant, $R = 8.31 \text{ J/(mol} \bullet \text{K)}$	Acceleration due to gravity at Earth's surface, $g = 9.8$ m/s²
Boltzmann's constant, $k_B = 1.38 \times 10^{-23} \text{J/K}$	

1 unified atomic mass unit, $1 \text{ u} = 1.66 \times 10^{-27} \text{ kg} = 931 \text{ MeV}/c^2$

Planck's constant, $h = 6.63 \times 10^{-34} \text{ J} \bullet \text{s} = 4.14 \times 10^{-15} \text{ eV} \bullet \text{s}$

$hc = 1.99 \times 10^{-25} \text{ J} \bullet \text{m} = 1.24 \times 10^{3} \text{ eV} \bullet \text{nm}$

Vacuum permittivity, $\varepsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/(\text{N} \bullet \text{m}^2)$

Coulomb's law constant, $k = 1/4\pi\varepsilon_0 = 9.0 \times 10^{9} \text{ N}\bullet\text{m}^2/\text{C}^2$

Vacuum permeability, $\mu_0 = 4\pi \times 10^{-7} \text{ (T} \bullet \text{m)/A}$

Magnetic constant, $k' = \frac{\mu_0}{4\pi} = 1 \times 10^{-7} \text{ (T} \bullet \text{m)/A}$

1 atmosphere pressure, $1 \text{ atm} = 1.0 \times 10^{5} \frac{\text{N}}{\text{m}^2} = 1.0 \times 10^{5} \text{ Pa}$

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,	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

θ	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	$\sqrt{3/3}$	¾	1	4/3	$\sqrt{3}$	∞

ADVANCED PLACEMENT PHYSICS 2 EQUATIONS

MECHANICS

Equation	Usage	
$v_x = v_{x0} + a_x t$ $x = x_0 + v_{x0}t + \frac{1}{2}a_x t^2$ $v_x^2 = v_{x0}^2 + 2a_x(x - x_0)$	Kinematic relationships for an object accelerating uniformly in one dimension. Can be applied in both *x* and *y* directions.	a = acceleration A = amplitude d = distance E = energy F = force f = frequency 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 = speed W = work done on a system x = position y = height α = angular acceleration μ = coefficient of friction θ = angle τ = torque ω = angular speed
$\overrightarrow{a} = \frac{\Sigma\vec{F}}{m} = \frac{\vec{F}_{net}}{m}$ $\vec{a} = \frac{\Sigma\vec{\tau}}{I} = \frac{\vec{\tau}_{net}}{I}$	Force exerted on an object due to the interaction of that object with another object.	
$\vec{p} = m\vec{v}$	Defines momentum for a single object moving with some velocity.	
$\Delta\vec{p} = \vec{F}\Delta t$	Average change in momentum or impulse	
$\lvert\vec{F}_f\rvert \leq \mu \lvert\vec{F}_n\rvert$	The relationship for the frictional force acting on an object on a rough surface.	
$\lvert\overrightarrow{F_S}\rvert = k\lvert\vec{x}\rvert$	Static friction	
$U_s = \frac{1}{2}kx^2$	Elastic/spring potential energy	
$K = \frac{1}{2}mv^2$	The definition of kinetic energy.	
$\Delta E = W = F_{\parallel}d = Fdcos\theta$	Energy transfer	
$P = \frac{\Delta E}{\Delta t}$	Power is defined as the rate of energy transfer into, out of, or within a system.	
$\Delta U_g = mg\Delta y$	Gravitational potential energy	
$a_c = \frac{v^2}{r}$	Centripetal acceleration Angular velocity	
$\vec{\tau} = r_{\perp}F = rF\sin\theta$	The definition of torque.	
$x_{cm} = \frac{\sum \square_i x_i}{\sum m_i}$	Calculate the center of mass for a nonuniform solid that can be considered as a collection of regular masses or for a system of masses.	
$K = \frac{1}{2}I\omega^2$	Kinetic energy in a rotating object.	
$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$ $\omega = \omega_0 + \alpha t$	The angular kinematic relationships for objects experiencing a uniform angular acceleration.	
$x = Acos(\omega t)$ $= Acos(2\pi f t)$	A simple wave can be described by an equation involving one sine or cosine function involving the wavelength, amplitude, and frequency of the wave.	
$L = I\omega$	Angular momentum	

$\Delta L = \tau \Delta t$		
$T = \frac{2\pi}{\omega} = \frac{1}{f}$	The period of simple harmonic motion (SHM) is related to the angular frequency.	
$T_s = 2\pi\sqrt{\frac{m}{k}}$ $T_p = 2\pi\sqrt{\frac{l}{g}}$	The period of a system oscillating in simple harmonic motion (SHM), or its equivalent for a pendulum or physical pendulum, and this can be shown to be true experimentally from a plot of the appropriate data.	
$\lvert\vec{F}_g\rvert = G\frac{m_1 m_2}{r^2}$	The magnitude of the gravitational force between two masses can be determined by using Newton's universal law of gravitation.	
$\vec{g} = \frac{\vec{F}_g}{m}$	Gravitational force	
$U_g = -\frac{G m_1 m_2}{r}$	The gravitational potential energy of the object-Earth system (shown using the relationship between the conservative force and potential energy.	

ELECTRICITY AND MAGNETISM		
Equation	**Usage**	
$\lvert\vec{F}_E\rvert = \frac{1}{4\pi\varepsilon_0}\left\lvert\frac{q_1 q_2}{r^2}\right\rvert$	Coulomb's Law; gives the magnitude of electromagnetic force between two point charges.	A = area B = magnetic field C = capacitance d = distance E = electric field $\mathcal{E}$ = emf F = force I = current ℓ = length P = power Q = charge q = point charge R = resistance r = separation t = time U = potential or stored energy V = electric potential v = speed κ = dielectric constant ρ = resistivity θ = angle Φ = flux
$\vec{E} = \frac{\vec{F}_E}{q}$	The definition of electric field.	
$\lvert\vec{E}\rvert = \frac{1}{4\pi\varepsilon_0}\frac{\lvert q\rvert}{r^2}$	Gives the magnitude of the electric field at a distance from the center of a source object of electric charge.	
$\Delta U_E = q\Delta V$	Changes in a system's internal structure can result in changes in internal energy.	
$E = \frac{Q}{\varepsilon_0 A}$	Calculate magnitude of an electric field between two oppositely charged parallel plates with uniformly distributed electric charge.	
$\lvert\vec{E}\rvert = \left\lvert\frac{\Delta V}{\Delta r}\right\rvert$	The average value of the electric field in a region	

$B = \frac{\mu_0}{2\pi}\frac{I}{r}$	Magnitude of a magnetic field
$\vec{F}_M = q\vec{v} \times \vec{B}$	The magnetic force of interaction between a moving charged particle and a uniform magnetic field.
$\|\vec{F}_M\| = \|q\vec{v}\|\|\sin\theta\|\|\vec{B}\|$	The magnetic force depends on the angle between the velocity and the magnetic field vectors.
$\vec{F}_M = I\vec{\ell} \times \vec{B}$	A magnetic force results from the interaction of a moving charged object or a magnet with other moving charged objects or another magnet.
$\|\vec{F}_M\| = \|I\vec{\ell}\|\|\sin\theta\|\|\vec{B}\|$	The force exerted on a moving charged object is perpendicular to both the magnetic field and the velocity of the charge and is described by a right-hand rule.
$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$	Isolines
$\Phi_B = \vec{B} \bullet \vec{A}$ $\Phi_B = \|\vec{B}\|\cos\theta\|\vec{A}\|$ $\varepsilon = B\ell v$ $\varepsilon = -\frac{\Delta\Phi_B}{\Delta t}$	Changing magnetic flux
$\Delta V = \frac{Q}{C}$	Calculates the energy stored in a capacitor.
$C = \frac{\kappa\varepsilon_0 A}{d}$	Calculates the capacitance of a parallel-plate capacitor with a dielectric material inserted between the plates.
$C_p = \sum_i C_i$	Can be used to determine the equivalent capacitance of capacitors arranged in parallel.
$\frac{1}{C_S} = \sum_i \frac{1}{C_i}$	Can be used to determine the equivalent capacitance of capacitors arranged in series.
$I = \frac{\Delta Q}{\Delta t}$	An electrical current is a movement of charge through a conductor.
$U_C = \frac{1}{2}Q\Delta V = \frac{1}{2}C(\Delta V)^2$	The energy stored in a capacitor. The electrical potential energy stored in a capacitor.
$R = \frac{\rho\ell}{A}$	The definition of resistance in terms of the properties of the conductor.
$I = \frac{\Delta V}{R}$	Ohm's Law
$R_S = \sum_i R_i$	The rule for equivalent resistance for resistors arranged in series.
$\frac{1}{R_p} = \sum_i \frac{1}{R_i}$	The rule for equivalent resistance for resistors arranged in parallel.
$P = I\Delta V$	The definition of power or the rate of heat loss through a resistor.

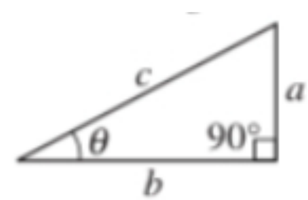
FLUID PHYSICS AND THERMAL MECHANICES		
EQUATION	**USAGE**	
$\rho = \frac{m}{V}$	Calculate density	

$P = \frac{F}{A}$	Calculate force	A = area F = force h = depth k = thermal conductivity K = kinetic energy L = thickness m = mass n = number of moles N = number of molecules P = pressure Q = energy transferred to a system by heating T = temperature t = time U = internal energy V = volume v = speed W = work done on a system y = height ρ = density
$P = P_0 + \rho g h$	Calculate absolute pressure	
$F_b = \rho g h$	Calculate contact force	
$A_1 v_1 = A_2 v_2$	Continuity equation (used to describe conservation of mass flow rate in fluids)	
$P_1 + \rho g y_1 + \frac{1}{2}\rho v_1^2 = P_2 + \rho g y_2 + \frac{1}{2}\rho v_2^2$	Bernoulli's equation (describes the conservation of energy in fluid flow) Calculate pressure	
$\frac{Q}{\Delta t} = \frac{kA\Delta T}{L}$	Thermal conductivity is the measure of a material's ability to transfer thermal energy.	
$PV = nRT - Nk_B T$	The ideal gas law	
$K = \frac{3}{2} k_B T$	Calculate the average kinetic energy of a system	
$W = -P\Delta V$	Defines the work done on a system.	
$\Delta W = Q + W$	Change in internal energy of a system involves the possible transfer of energy through work and/or heat.	

WAVES AND OPTICS		
EQUATION	**USAGE**	d = separation f = frequency or focal length h = height L = distance M = magnification m = an integer n = index of refraction s = distance v = speed λ = wavelength θ = angle
$\lambda = \frac{v}{f}$	Wavelength	
$n = \frac{c}{v}$	Refraction	
$n_1 \sin\theta_1 = n_2 \sin\theta_2$	Snell's Law	
$\frac{1}{s_i} + \frac{1}{s_0} = \frac{1}{f}$ $\lvert M \rvert = \left\lvert \frac{h_i}{h_o} \right\rvert = \frac{s_i}{s_o}$	Law of reflection	
$\Delta L = m\lambda$ $d\sin\theta = m\lambda$	Diffraction	

MODERN PHYSICS		
EQUATION	**USAGE**	E = energy

$E = hf$	Energy of a photon	F = frequency K = kinetic energy m = mass p = momentum λ = wavelength ϕ = work function
$K_{max} = hf - \phi$	Photoelectric effect	
$\lambda = \frac{h}{p}$	Wavelength of a particle	
$E = mc^2$	Equation derived from the theory of special relativity.	

GEOMETRY AND TRIGONOMETRY		
Equation	**Usage**	A = area C = circumference V = volume S = surface area b = base h = height ℓ = length w = width r = radius
$A = bh$	Area of a rectangle	
$A = \frac{1}{2}bh$	Area of a triangle	
$A = \pi r^2$ $C = 2\pi r$	Area of a circle Circumference of a circle	
$V = \ell wh$	Volume of a rectangular solid	
$V = \pi r^2 \ell$ $S = 2\pi r\ell + 2\pi r^2$	Volume of a cylinder Surface area of a cylinder	
$V = \frac{4}{3}\pi r^3$ $S = 4\pi r^2$	Volume of a sphere Surface area of a sphere	
Pythagorean theorem Calculate the value of the angles of a right triangle	$c^2 = a^2 + b^2$ $\sin\theta = \frac{a}{c}$ $\cos\theta = \frac{b}{c}$ $\tan\theta = \frac{a}{b}$	

The following assumptions are used in this exam.

I. The frame of reference of any problem is inertial unless otherwise stated.
II. The direction of current is the direction in which positive charges would drift.
III. The electric potential is zero at an infinite distance from an isolated point charge.
IV. All batteries and meters are ideal unless otherwise stated.
V. Edge effects for the electric field of a parallel plate capacitor are negligible unless otherwise stated.