ADVANCED PLACEMENT PHYSICS C TABLE OF INFORMATION

CONSTANTS AND CONVERSION FACTORS

Proton mass, $m_p = 1.67 \times 10^{-27}$ kg

Neutron mass, $m_n = 1.67 \times 10^{-27}$ kg

Electron mass, $m_e = 9.11 \times 10^{-31}$ kg

Avogadro's number, $N_0 = 6.02\ x\ 10^{23} \text{mol}^{-1}$

Universal gas content, $R = 8.31 \text{ J}/(\text{mol} \bullet \text{K})$

Boltzmann's constant, $k_B = 1.38 \times 10^{-23} \text{J/K}$

Electron charge magnitude, $e = 1.60 \times 10^{-19}$ C

1 electron volt, $1 \text{ eV} = 1.60 \times 10^{-19}$ J

Speed of light, $c = 3.00 \times 10^8$ m/s

Universal gravitational constant, $G = 6.67 \times 10^{-11}$ m³/kg•s²

Acceleration due to gravity at Earth's surface, $g = 9.8$ m/s²

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

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

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
10^9	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 C EQUATIONS

<table>
<tr><th colspan="3">MECHANICS</th></tr>
<tr><th>Equation</th><th>Usage</th><td rowspan="16">a = acceleration
E = energy
F = force
f = frequency
h = height
I = rotational inertia
J = impulse
K =kinetic energy
k = spring constant
ℓ = length
L = angular momentum
m = mass
P =power
p = momentum
r = radius or distance
T = period
t = time
U = potential energy
V = volume
v = velocity or speed
W = work done on a system
x = position
μ = coefficient of friction
θ = angle
τ = torque
ω = angular speed
α = angular acceleration
ϕ = phase angle</td></tr>
<tr><td>$v_x = v_{x0} + a_x t$
$x = x_0 + v_{x0}t + \frac{1}{2}a_x t^2$
$v_x^2 = v_{x0}^2 + 2a_x(x - x_0)$</td><td>Kinematic relationships for an object accelerating uniformly in one dimension. Can be applied in both *x* and *y* directions.</td></tr>
<tr><td>$\overrightarrow{a} = \frac{\Sigma\vec{F}}{m} = \frac{\vec{F}_{net}}{m}$
$\vec{a} = \frac{\Sigma\vec{\tau}}{I} = \frac{\vec{\tau}_{net}}{I}$</td><td>Newton's second law.
Newton's second law for rotation.</td></tr>
<tr><td>$\vec{F} = \frac{d\vec{p}}{dt}$</td><td>The total momentum of the system is the vector sum of the momenta of the individual objects. The rate of change of momentum is equal to the net external force.</td></tr>
<tr><td>$\vec{J} = \int \vec{F}dt = \Delta\vec{p}$</td><td>Impulse is defined as the average force acting over a time interval.
Impulse is also equivalent to the change in momentum of the object receiving the impulse.</td></tr>
<tr><td>$\vec{p} = m\vec{v}$</td><td>Defines momentum for a single object moving with some velocity.</td></tr>
<tr><td>$\left|\vec{F}_f\right| \leq \mu \left|\vec{F}_n\right|$</td><td>The relationship for the frictional force acting on an object on a rough surface.</td></tr>
<tr><td>$\Delta E = W = \int \vec{F} \bullet d\vec{r}$</td><td>Calculate the work done on an object by a force</td></tr>
<tr><td>$K = \frac{1}{2}mv^2$</td><td>The definition of kinetic energy.</td></tr>
<tr><td>$P = \frac{dE}{dt}$</td><td>Defines power.</td></tr>
<tr><td>$P = \vec{F} \bullet \vec{v}$</td><td>Defines power.</td></tr>
<tr><td>$\Delta U_g = mg\Delta h$</td><td>The definition of the gravitational potential energy of a system consisting of the Earth and on object of mass *m* near the surface of the Earth.</td></tr>
<tr><td>$a_c = \frac{v^2}{r} = \omega^2 r$</td><td>Centripetal acceleration
Angular velocity</td></tr>
<tr><td>$\vec{\tau} = \vec{r} \times \vec{F}$</td><td>The definition of torque.</td></tr>
<tr><td>$I = \int r^2 dm = \Sigma mr^2$</td><td>The general definition of moment of inertia.
The calculus definition of moment of</td></tr>
</table>

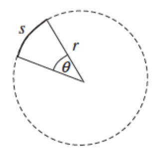
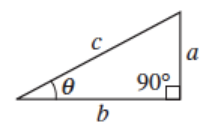
	inertia.	
$x_{cm} = \frac{\sum m_i x_i}{\sum m_i}$	Calculate the center of mass for a nonuniform solid that can be considered as a collection of regular masses or for a system of masses.	
$v = r\omega$	The angular motion is related to the linear translational motion for objects that are rolling without slipping on a surface.	
$\vec{L} = \vec{r} \times \vec{p} = I\vec{\omega}$	The definition of angular momentum of a rotating rigid body.	
$K = \frac{1}{2} I\omega^2$	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.	
$\vec{F_s} = -k\Delta\vec{x}$	Spring potential energy.	
$U_s = \frac{1}{2} k(\Delta x)^2$	Show the potential energy for an ideal spring using the general relationship between conservative force and potential energy.	
$x = x_{max} \cos(\omega t + \phi)$	The general relationship for simple harmonic motion (SHM).	
$T = \frac{2\pi}{\omega} = \frac{1}{f}$	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.	
$U_g = -\frac{Gm_1 m_2}{r}$	The gravitational potential energy of the object-Earth system (shown using the relationship between the conservative force and potential energy.	

ADVANCED PLACEMENT PHYSICS C EQUATIONS

ELECTRICITY AND MAGNETISM

Equation	Usage	
$\left\|\vec{F}_E\right\| = \frac{1}{4\pi\varepsilon_0}\left\|\frac{q_1 q_2}{r^2}\right\|$	Coulomb's Law; gives the magnitude of electrostatic force between two point charges.	A = area B = magnetic field C = capacitance d = distance E = electric field $\mathcal{E}$ = emf F = force I = current J = current density L = inductance ℓ = length n = number of loops of wire per unit length N = number of charge carriers per unit volume P = power Q = charge q = point charge R = resistance r = radius or distance t = time U = potential or stored energy V = electric potential v = velocity or speed ρ = resistivity Φ = flux κ = dielectric constant
$\vec{E} = \frac{\vec{F}_E}{q}$	The definition of electric field.	
$\oint E \bullet dA = \frac{Q}{\mathcal{E}_0}$ $\varepsilon = \oint \vec{E} \bullet d\vec{\ell} = -\frac{d\Phi_B}{dt}$	Gauss's Law. Can help in describing features of electric fields of charged systems at the surface, inside the surface, or at some distance away from the surface of charged objects. Can be useful in determining the charge distribution that created an electric field.	
$\Delta V = -\int \vec{E} \bullet d\vec{r}$ $E_x = -\frac{dV}{dx}$	The general definition of potential difference that can be used in most cases. The differential form.	
$V = \frac{1}{4\mu\varepsilon_0}\sum_i \frac{q_i}{r_i}$	Can be used to determine the potential due to multiple point charges by the principle of superposition in scalar terms of the charge.	
$U_E = qV = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r}$	The electrostatic potential energy of two point charges near each other.	
$\Delta V = \frac{Q}{C}$	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.	
$I = \frac{dQ}{dt}$	The definition of current.	
$U_C = \frac{1}{2}Q\Delta V = \frac{1}{2}C(\Delta V)^2$	The energy stored in a capacitor.	

	The electrical potential energy stored in a capacitor.
$R = \dfrac{\rho \ell}{A}$	The definition of resistance in terms of the properties of the conductor.
$\vec{E} = \rho \vec{J}$	The relationship that defines current density (current per cross-sectional area) in a conductor.
$I = N e v_d A$	The definition of current in a conductor.
$I = \dfrac{\Delta V}{R}$	Ohm's Law
$R_S = \sum_i R_i$	The rule for equivalent resistance for resistors arranged in series.
$\dfrac{1}{R_p} = \sum_i \dfrac{1}{R_i}$	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.
$\vec{F}_M = q\vec{v} \times \vec{B}$	The magnetic force of interaction between a moving charged particle and a uniform magnetic field.
$\oint \vec{B} \bullet d\vec{\ell} = \mu_0 I$	Ampère's Law (a fundamental law of magnetism that relates the magnitude of the magnetic field to the current enclosed by a closed imaginary path called an Amperian loop) in integral form.
$d\vec{B} = \dfrac{\mu_0}{4\pi} \dfrac{I d\vec{\ell} \times \hat{r}}{r^2}$	The Biot-Savart Law (the fundamental law of magnetism that defines the magnitude and direction of a magnetic field due to moving charges or current-carrying conductors in differential form
$\vec{F} = \int I d\vec{\ell} \times \vec{B}$	The definition of the magnetic force acting on a straight-line segment of a current-carrying conductor in a uniform magnetic field.
$B_S = \mu_0 n I$	Can be used to determine the magnetic field inside a solenoid.
$\Phi_B = \int \vec{B} \bullet d\vec{A}$	The definition of magnetic flux.
$\varepsilon = -L \dfrac{dI}{dt}$	Faraday's Law.
$U_L = \dfrac{1}{2} L I^2$	The stored energy in an inductor.

GEOMETRY AND TRIGONOMETRY		
Equation	**Usage**	
$A = bh$	Rectangle	A = area C = circumference V = volume S = surface area b = base h = height ℓ = length w = width r = radius s = arc length θ = angle
$A = \frac{1}{2}bh$	Triangle	
$A = \pi r^2$ $C = 2\pi r$ $s = r\theta$	Circle	
$V = \ell wh$	Rectangular Solid	
$V = \pi r^2 \ell$ $S = 2\pi r\ell + 2\pi r^2$	Cylinder	
$V = \frac{4}{3}\pi r^3$ $S = 4\pi r^2$	Sphere	
$a^2 + b^2 = c^2$ $\sin\theta = \frac{a}{c}$ $\cos\theta = \frac{b}{c}$ $\tan\theta = \frac{a}{b}$	Right Triangle	 

CALCULUS
$\frac{df}{dx} = \frac{df}{du}\frac{du}{dx}$
$\frac{d}{dx}(x^n) = nx^{n-1}$
$\frac{d}{dx}(e^{ax}) = ae^{ax}$
$\frac{d}{dx}(\ln ax) = \frac{1}{x}$
$\frac{d}{dx}[\sin(ax)] = a\cos(ax)$
$\frac{d}{dx}[\cos(ax)] = -a\sin(ax)$
$\int x^n dx = \frac{1}{n+1}x^{n+1}, n \neq -1$
$\int e^{ax} dx = \frac{1}{a}e^{ax}$
$\int \frac{dx}{x+a} = 1n\|x+a\|$
$\int \cos(ax)dx = \frac{1}{a}\sin(ax)$
$\int \sin(ax)dx = -\frac{1}{a}\cos(ax)$
VECTOR PRODUCTS
$\vec{A} \bullet \vec{B} = AB\cos\theta$
$\|\vec{A} \times \vec{B}\| = AB\sin\theta$

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.