

## ADVANCED PLACEMENT PHYSICS C EQUATIONS

### MECHANICS

$v_x = v_{x0} + a_x t$ $x = x_0 + v_{x0} t + \frac{1}{2} a_x t^2$ $v_x^2 = v_{x0}^2 + 2a_x(x - x_0)$ $\bar{a} = \frac{\sum \vec{F}}{m} = \frac{\vec{F}_{net}}{m}$ $\vec{F} = \frac{d\vec{p}}{dt}$ $\vec{J} = \int \vec{F} dt = \Delta\vec{p}$ $\vec{p} = m\vec{v}$ $ \vec{F}_f  \leq \mu  \vec{F}_N $ $\Delta E = W = \int \vec{F} \cdot d\vec{r}$ $K = \frac{1}{2} m v^2$ $P = \frac{dE}{dt}$ $P = \vec{F} \cdot \vec{v}$ $\Delta U_g = mg\Delta h$ $a_c = \frac{v^2}{r} = \omega^2 r$ $\vec{\tau} = \vec{r} \times \vec{F}$ $\bar{\alpha} = \frac{\sum \vec{\tau}}{I} = \frac{\vec{\tau}_{net}}{I}$ $I = \int r^2 dm = \sum mr^2$ $x_{cm} = \frac{\sum m_i x_i}{\sum m_i}$ $v = r\omega$ $\vec{L} = \vec{r} \times \vec{p} = I\vec{\omega}$ $K = \frac{1}{2} I \omega^2$ $\omega = \omega_0 + \alpha t$ $\theta = \theta_0 + \omega_0 t + \frac{1}{2} \alpha t^2$	<p><math>a</math> = acceleration  <math>E</math> = energy  <math>F</math> = force  <math>f</math> = frequency  <math>h</math> = height  <math>I</math> = rotational inertia  <math>J</math> = impulse  <math>K</math> = kinetic energy  <math>k</math> = spring constant  <math>\ell</math> = length  <math>L</math> = angular momentum  <math>m</math> = mass  <math>P</math> = power  <math>p</math> = momentum  <math>r</math> = radius or distance  <math>T</math> = period  <math>t</math> = time  <math>U</math> = potential energy  <math>v</math> = velocity or speed  <math>W</math> = work done on a system  <math>x</math> = position  <math>\mu</math> = coefficient of friction  <math>\theta</math> = angle  <math>\tau</math> = torque  <math>\omega</math> = angular speed  <math>\alpha</math> = angular acceleration  <math>\phi</math> = phase angle</p> $\vec{F}_s = -k\Delta\vec{x}$ $U_s = \frac{1}{2} k (\Delta x)^2$ $x = x_{max} \cos(\omega t + \phi)$ $T = \frac{2\pi}{\omega} = \frac{1}{f}$ $T_s = 2\pi \sqrt{\frac{m}{k}}$ $T_p = 2\pi \sqrt{\frac{\ell}{g}}$ $ \vec{F}_G  = \frac{Gm_1 m_2}{r^2}$ $U_G = -\frac{Gm_1 m_2}{r}$
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### ELECTRICITY AND MAGNETISM

$ \vec{F}_E  = \frac{1}{4\pi\epsilon_0} \left  \frac{q_1 q_2}{r^2} \right $ $\vec{E} = \frac{\vec{F}_E}{q}$ $\oint \vec{E} \cdot d\vec{A} = \frac{Q}{\epsilon_0}$ $E_x = -\frac{dV}{dx}$ $\Delta V = -\int \vec{E} \cdot d\vec{r}$ $V = \frac{1}{4\pi\epsilon_0} \sum_i \frac{q_i}{r_i}$ $U_E = qV = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r}$ $\Delta V = \frac{Q}{C}$ $C = \frac{\kappa \epsilon_0 A}{d}$ $C_p = \sum_i C_i$ $\frac{1}{C_s} = \sum_i \frac{1}{C_i}$ $I = \frac{dQ}{dt}$ $U_C = \frac{1}{2} Q \Delta V = \frac{1}{2} C (\Delta V)^2$ $R = \frac{\rho \ell}{A}$ $\vec{E} = \rho \vec{J}$ $I = Nev_d A$ $I = \frac{\Delta V}{R}$ $R_s = \sum_i R_i$ $\frac{1}{R_p} = \sum_i \frac{1}{R_i}$ $P = I \Delta V$	<p><math>A</math> = area  <math>B</math> = magnetic field  <math>C</math> = capacitance  <math>d</math> = distance  <math>E</math> = electric field  <math>\mathcal{E}</math> = emf  <math>F</math> = force  <math>I</math> = current  <math>J</math> = current density  <math>L</math> = inductance  <math>\ell</math> = length  <math>n</math> = number of loops of wire per unit length  <math>N</math> = number of charge carriers per unit volume  <math>P</math> = power  <math>Q</math> = charge  <math>q</math> = point charge  <math>R</math> = resistance  <math>r</math> = radius or distance  <math>t</math> = time  <math>U</math> = potential or stored energy  <math>V</math> = electric potential  <math>v</math> = velocity or speed  <math>\rho</math> = resistivity  <math>\Phi</math> = flux  <math>\kappa</math> = dielectric constant</p> $\vec{F}_M = q\vec{v} \times \vec{B}$ $\oint \vec{B} \cdot d\vec{\ell} = \mu_0 I$ $d\vec{B} = \frac{\mu_0}{4\pi} \frac{I d\vec{\ell} \times \hat{r}}{r^2}$ $\vec{F} = \int I d\vec{\ell} \times \vec{B}$ $B_s = \mu_0 n I$ $\Phi_B = \int \vec{B} \cdot d\vec{A}$ $\mathcal{E} = \oint \vec{E} \cdot d\vec{\ell} = -\frac{d\Phi_B}{dt}$ $\mathcal{E} = -L \frac{dI}{dt}$ $U_L = \frac{1}{2} L I^2$
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ADVANCED PLACEMENT PHYSICS C 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, $N_0 = 6.02 \times 10^{23}$ mol <sup>-1</sup>	Universal gravitational constant, $G = 6.67 \times 10^{-11}$ (N·m <sup>2</sup> )/kg <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	
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	

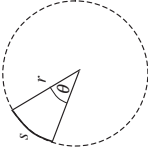

PREFIXES	
Factor	Prefix Symbol
10 <sup>9</sup>	giga G
10 <sup>6</sup>	mega M
10 <sup>3</sup>	kilo k
10 <sup>-2</sup>	centi c
10 <sup>-3</sup>	milli m
10 <sup>-6</sup>	micro μ
10 <sup>-9</sup>	nano n
10 <sup>-12</sup>	pico p

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 assumptions are used in this exam.

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

ADVANCED PLACEMENT PHYSICS C EQUATIONS

GEOMETRY AND TRIGONOMETRY	CALCULUS:
<p>Rectangle  <math>A = bh</math>                      Triangle  <math>A = \frac{1}{2}bh</math>                      Circle  <math>A = \pi r^2</math>  <math>C = 2\pi r</math>  <math>s = r\theta</math>                      Rectangular Solid  <math>V = \ell wh</math>                      Cylinder  <math>V = \pi r^2 \ell</math>  <math>S = 2\pi r \ell + 2\pi r^2</math>                      Sphere  <math>V = \frac{4}{3}\pi r^3</math>  <math>S = 4\pi r^2</math></p>	<p> <math>\frac{df}{dx} = \frac{df}{du} \frac{du}{dx}</math>  <math>\frac{d}{dx}(x^n) = nx^{n-1}</math>  <math>\frac{d}{dx}(e^{ax}) = ae^{ax}</math>  <math>\frac{d}{dx}(\ln ax) = \frac{1}{x}</math>  <math>\frac{d}{dx}[\sin(ax)] = a \cos(ax)</math>  <math>\frac{d}{dx}[\cos(ax)] = -a \sin(ax)</math>  <math>\int x^n dx = \frac{1}{n+1} x^{n+1}, n \neq -1</math>  <math>\int e^{ax} dx = \frac{1}{a} e^{ax}</math>  <math>\int \frac{dx}{x+a} = \ln x+a </math>  <math>\int \cos(ax) dx = \frac{1}{a} \sin(ax)</math>  <math>\int \sin(ax) dx = -\frac{1}{a} \cos(ax)</math></p>
<p> <math>A = \text{area}</math>  <math>C = \text{circumference}</math>  <math>V = \text{volume}</math>  <math>S = \text{surface area}</math>  <math>b = \text{base}</math>  <math>h = \text{height}</math>  <math>\ell = \text{length}</math>  <math>w = \text{width}</math>  <math>r = \text{radius}</math>  <math>s = \text{arc length}</math>  <math>\theta = \text{angle}</math> </p>  	<p><b>VECTOR PRODUCTS:</b>  <math>\vec{A} \cdot \vec{B} = AB \cos \theta</math>  <math> \vec{A} \times \vec{B}  = AB \sin \theta</math></p>
<p>Right Triangle  <math>a^2 + b^2 = c^2</math>  <math>\sin \theta = \frac{a}{c}</math>  <math>\cos \theta = \frac{b}{c}</math>  <math>\tan \theta = \frac{a}{b}</math></p>	