

# 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, $N_0 = 6.02 \times 10^{23} \text{ mol}^{-1}$   | Universal gravitational constant, $G = 6.67 \times 10^{-11} (\text{N}\cdot\text{m}^2)/\text{kg}^2$ |
| Universal gas constant, $R = 8.31 \text{ J}/(\text{mol}\cdot\text{K})$                                  | Acceleration due to gravity at Earth's surface, $g = 9.8 \text{ m/s}^2$                            |
| 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,  | $h = 6.63 \times 10^{-34} \text{ J}\cdot\text{s} = 4.14 \times 10^{-15} \text{ eV}\cdot\text{s}$   |
|   | $hc = 1.99 \times 10^{-25} \text{ J}\cdot\text{m} = 1.24 \times 10^3 \text{ eV}\cdot\text{nm}$     |
| Vacuum permittivity,  | $\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/(\text{N}\cdot\text{m}^2)$                          |
| Coulomb's law constant, $k = 1/(4\pi\epsilon_0) = 9.0 \times 10^9 (\text{N}\cdot\text{m}^2)/\text{C}^2$ |  |
| Vacuum permeability,  | $\mu_0 = 4\pi \times 10^{-7} (\text{T}\cdot\text{m})/\text{A}$                                     |
| Magnetic constant, $k' = \mu_0/(4\pi) = 1 \times 10^{-7} (\text{T}\cdot\text{m})/\text{A}$              |  |
| 1 atmosphere pressure,  | $1 \text{ atm} = 1.0 \times 10^5 \text{ N/m}^2 = 1.0 \times 10^5 \text{ Pa}$                       |

|                 |              |            |               |                    |
|-----------------|--------------|------------|---------------|--------------------|
| UNIT<br>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, $\Omega$ | electron volt, eV  |
|                 | kelvin, K    | joule, J   | 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  | $\mu$  |
| $10^{-9}$  | nano   | n      |
| $10^{-12}$ | pico   | p      |

| VALUES OF TRIGONOMETRIC FUNCTIONS FOR COMMON ANGLES |           |              |            |              |            |              |            |
|---|-----------|--------------|------------|--------------|------------|--------------|------------|
| $\theta$  | $0^\circ$ | $30^\circ$   | $37^\circ$ | $45^\circ$   | $53^\circ$ | $60^\circ$   | $90^\circ$ |
| $\sin \theta$                                       | 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            | $4/3$      | $\sqrt{3}$   | $\infty$   |

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.

# ADVANCED PLACEMENT PHYSICS C EQUATIONS

## MECHANICS

$$v_x = v_{x0} + a_x t$$

$$x = x_0 + v_{x0} t + \frac{1}{2} a_x t^2$$

$$v_x^2 = v_{x0}^2 + 2a_x(x - x_0)$$

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

$$\vec{F} = \frac{d\vec{p}}{dt}$$

$$\vec{J} = \int \vec{F} dt = \Delta \vec{p}$$

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

$$|\vec{F}_f| \leq \mu |\vec{F}_N|$$

$$\Delta E = W = \int \vec{F} \cdot d\vec{r}$$

$$K = \frac{1}{2} m v^2$$

$$P = \frac{dE}{dt}$$

$$P = \vec{F} \cdot \vec{v}$$

$$\Delta U_g = mg \Delta h$$

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

$$\vec{\tau} = \vec{r} \times \vec{F}$$

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

$$I = \int r^2 dm = \sum m r^2$$

$$x_{cm} = \frac{\sum m_i x_i}{\sum m_i}$$

$$v = r \omega$$

$$\vec{L} = \vec{r} \times \vec{p} = I \vec{\omega}$$

$$K = \frac{1}{2} I \omega^2$$

$$\omega = \omega_0 + \alpha t$$

$$\theta = \theta_0 + \omega_0 t + \frac{1}{2} \alpha t^2$$

$$a = \text{acceleration}$$

$$E = \text{energy}$$

$$F = \text{force}$$

$$f = \text{frequency}$$

$$h = \text{height}$$

$$I = \text{rotational inertia}$$

$$J = \text{impulse}$$

$$K = \text{kinetic energy}$$

$$k = \text{spring constant}$$

$$\ell = \text{length}$$

$$L = \text{angular momentum}$$

$$m = \text{mass}$$

$$P = \text{power}$$

$$p = \text{momentum}$$

$$r = \text{radius or distance}$$

$$T = \text{period}$$

$$t = \text{time}$$

$$U = \text{potential energy}$$

$$v = \text{velocity or speed}$$

$$W = \text{work done on a system}$$

$$x = \text{position}$$

$$\mu = \text{coefficient of friction}$$

$$\theta = \text{angle}$$

$$\tau = \text{torque}$$

$$\omega = \text{angular speed}$$

$$\alpha = \text{angular acceleration}$$

$$\phi = \text{phase angle}$$

$$\vec{F}_s = -k \Delta \vec{x}$$

$$U_s = \frac{1}{2} k (\Delta x)^2$$

$$x = x_{\max} \cos(\omega t + \phi)$$

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

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

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

$$|\vec{F}_G| = \frac{G m_1 m_2}{r^2}$$

$$U_G = -\frac{G m_1 m_2}{r}$$

## ELECTRICITY AND MAGNETISM

$$|\vec{F}_E| = \frac{1}{4\pi\epsilon_0} \left| \frac{q_1 q_2}{r^2} \right|$$

$$\vec{E} = \frac{\vec{F}_E}{q}$$

$$\oint \vec{E} \cdot d\vec{A} = \frac{Q}{\epsilon_0}$$

$$E_x = -\frac{dV}{dx}$$

$$\Delta V = -\int \vec{E} \cdot d\vec{r}$$

$$V = \frac{1}{4\pi\epsilon_0} \sum_i \frac{q_i}{r_i}$$

$$U_E = qV = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r}$$

$$\Delta V = \frac{Q}{C}$$

$$C = \frac{\kappa \epsilon_0 A}{d}$$

$$C_p = \sum_i C_i$$

$$\frac{1}{C_s} = \sum_i \frac{1}{C_i}$$

$$I = \frac{dQ}{dt}$$

$$U_C = \frac{1}{2} Q \Delta V = \frac{1}{2} C (\Delta V)^2$$

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

$$\vec{E} = \rho \vec{J}$$

$$I = Ne v_d A$$

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

$$R_s = \sum_i R_i$$

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

$$P = I \Delta V$$

$$A = \text{area}$$

$$B = \text{magnetic field}$$

$$C = \text{capacitance}$$

$$d = \text{distance}$$

$$E = \text{electric field}$$

$$\mathcal{E} = \text{emf}$$

$$F = \text{force}$$

$$I = \text{current}$$

$$J = \text{current density}$$

$$L = \text{inductance}$$

$$\ell = \text{length}$$

$$n = \text{number of loops of wire per unit length}$$

$$N = \text{number of charge carriers per unit volume}$$

$$P = \text{power}$$

$$Q = \text{charge}$$

$$q = \text{point charge}$$

$$R = \text{resistance}$$

$$r = \text{radius or distance}$$

$$t = \text{time}$$

$$U = \text{potential or stored energy}$$

$$V = \text{electric potential}$$

$$v = \text{velocity or speed}$$

$$\rho = \text{resistivity}$$

$$\Phi = \text{flux}$$

$$\kappa = \text{dielectric constant}$$

$$\vec{F}_M = q\vec{v} \times \vec{B}$$

$$\oint \vec{B} \cdot d\vec{\ell} = \mu_0 I$$

$$d\vec{B} = \frac{\mu_0}{4\pi} \frac{I d\vec{\ell} \times \hat{r}}{r^2}$$

$$\vec{F} = \int I d\vec{\ell} \times \vec{B}$$

$$B_s = \mu_0 n I$$

$$\Phi_B = \int \vec{B} \cdot d\vec{A}$$

$$\mathcal{E} = \oint \vec{E} \cdot d\vec{\ell} = -\frac{d\Phi_B}{dt}$$

$$\mathcal{E} = -L \frac{dI}{dt}$$

$$U_L = \frac{1}{2} L I^2$$

# ADVANCED PLACEMENT PHYSICS C EQUATIONS

## GEOMETRY AND TRIGONOMETRY

Rectangle

$$A = bh$$

Triangle

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

Circle

$$A = \pi r^2$$

$$C = 2\pi r$$

$$s = r\theta$$

Rectangular Solid

$$V = \ell wh$$

Cylinder

$$V = \pi r^2 \ell$$

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

Sphere

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

$$S = 4\pi r^2$$

Right Triangle

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

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

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

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

$A$  = area

$C$  = circumference

$V$  = volume

$S$  = surface area

$b$  = base

$h$  = height

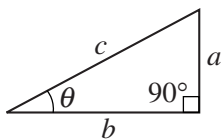
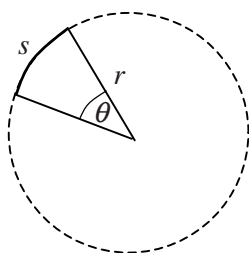
$\ell$  = length

$w$  = width

$r$  = radius

$s$  = arc length

$\theta$  = angle



## CALCULUS

$$\frac{df}{dx} = \frac{df}{du} \frac{du}{dx}$$

$$\frac{d}{dx}(x^n) = nx^{n-1}$$

$$\frac{d}{dx}(e^{ax}) = ae^{ax}$$

$$\frac{d}{dx}(\ln ax) = \frac{1}{x}$$

$$\frac{d}{dx}[\sin(ax)] = a \cos(ax)$$

$$\frac{d}{dx}[\cos(ax)] = -a \sin(ax)$$

$$\int x^n dx = \frac{1}{n+1} x^{n+1}, n \neq -1$$

$$\int e^{ax} dx = \frac{1}{a} e^{ax}$$

$$\int \frac{dx}{x+a} = \ln|x+a|$$

$$\int \cos(ax) dx = \frac{1}{a} \sin(ax)$$

$$\int \sin(ax) dx = -\frac{1}{a} \cos(ax)$$

## VECTOR PRODUCTS

$$\vec{A} \cdot \vec{B} = AB \cos \theta$$

$$|\vec{A} \times \vec{B}| = AB \sin \theta$$