Appendix: AP® Physics 2 Equation Tables

ADVANCED PLACEMENT PHYSICS 2, EFFECTIVE 2017

CONSTANTS AND CONVERSION FACTORS			
Proton mass,	$m_p = 1.67\times10^{-27}$ kg	Electron charge magnitude,	$e = 1.60\times10^{-19}$ C
Neutron mass,	$m_n = 1.67\times10^{-27}$ kg	1 electron volt,	$1\text{ eV} = 1.60\times10^{-19}$ J
Electron mass,	$m_e = 9.11\times10^{-31}$ kg	Speed of light,	$c = 3.00\times10^{8}\ \text{m/s}$
Avogadro's number,	$N_o = 6.02\times10^{23}\ \text{mol}^{-1}$	Universal gravitational constant,	$G = 6.67\times10^{-11}\ \text{m}^3/\text{kg}\cdot\text{s}^2$
Universal gas constant,	$R = 8.31\ \frac{\text{J}}{\text{mol}\cdot\text{K}}$	Acceleration due to gravity at Earth's surface,	$g = 9.8\ \text{m/s}^2$
Boltzmann's constant,	$k_B = 1.38\times10^{-23}\ \frac{\text{J}}{\text{K}}$		

1 unified atomic mass unit,	$1\text{ u} = 1.66\times10^{-27}\text{ kg} = 931\ \frac{\text{MeV}}{c^2}$
Planck's constant,	$h = 6.63\times10^{-34}\text{ J}\cdot\text{s} = 4.14\times10^{-15}\text{ eV}\cdot\text{s}$
	$hc = 1.99\times10^{-25}\text{ J}\cdot\text{m} = 1.24\times10^{-3}\text{ eV}\cdot\text{nm}$
Vacuum permittivity,	$\varepsilon_o = 8.85\times10^{-12}\ \frac{\text{C}^2}{\text{N}\cdot\text{m}^2}$
Coulomb's law constant,	$k = 1/4\pi\varepsilon_o = 9.0\times10^{9}\ \frac{\text{N}\cdot\text{m}^2}{\text{C}^2}$
Vacuum permeability,	$\mu_o = 4\pi\times10^{-7}\ \frac{\text{T}\cdot\text{m}}{\text{A}}$
Magnetic constant,	$k' = \mu_o/4\pi = 1\times10^{-7}\ \frac{\text{T}\cdot\text{m}}{\text{A}}$
1 atmosphere pressure,	$1\text{ atm} = 1.0\times10^{5}\ \frac{\text{N}}{\text{m}^2} = 1.0\times10^{5}\text{ Pa}$

UNIT SYMBOLS								
	meter,	m	mole	mol	watt,	W	farad,	F
	kilogram,	k	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

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	$\sqrt{3}/3$	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.

MECHANICS

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

$$x = x_o + v_{xo}t + \tfrac{1}{2}a_x t^2$$

$$v_x^2 = v_{xo}^2 + 2a_x(x - x_o)$$

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

$$|\vec{F}_f| \le \mu |\vec{F}_n|$$

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

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

$$\Delta\vec{p} = \vec{F}\Delta t$$

$$K = \tfrac{1}{2}mv^2$$

$$\Delta E = W = F_{\parallel}d = Fd\cos\theta$$

$$P = \frac{\Delta E}{\Delta t}$$

$$\theta = \theta_o + \omega_o t + \tfrac{1}{2}\alpha t^2$$

$$\omega = \omega_o + \alpha t$$

$$x = A\cos(\omega t) = A\cos(2\pi f t)$$

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

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

$$\tau = r_{\perp}F = rF\sin\theta$$

$$L = I\omega$$

$$\Delta L = \tau\Delta t$$

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

$$|\vec{F}_s| = k|\vec{x}|$$

$$U_s = \tfrac{1}{2}kx^2$$

$$\Delta U_g = mg\Delta y$$

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

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

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

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

$$\vec{g} = \frac{\vec{F}_g}{m}$$

$$U_g = G\frac{m_1 m_2}{r}$$

- a = acceleration
- A = amplitude
- d = distance
- E = energy
- f = frequency
- F = force
- 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 = volume
- v = speed
- W = work done on a system
- x = position
- y = height
- α = angular acceleration
- μ = coefficient of friction
- θ = angle
- ρ = density
- τ = torque
- ω = angular speed

ELECTRICITY AND MAGNETISM

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

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

$$|\vec{E}| = \frac{1}{4\pi\varepsilon_o}\frac{|q|}{r^2}$$

$$\Delta U_E = q\Delta V$$

$$V = \frac{1}{4\pi\varepsilon_o}\frac{q}{r}$$

$$|\vec{E}| = \left|\frac{\Delta V}{\Delta r}\right|$$

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

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

$$E = \frac{Q}{\varepsilon_o A}$$

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

$$I = \frac{\Delta Q}{\Delta t}$$

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

$$P = I\Delta V$$

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

$$R_s = \sum_i R_i$$

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

$$C_p = \sum_i C_i$$

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

$$B = \frac{\mu_o}{2\pi}\frac{I}{R}$$

- 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 (stored) energy
- V = electric potential
- v = speed
- κ = dielectric constant
- ρ = resistivity
- θ = angle
- Φ = flux

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

$$|\vec{F}_M| = |q\vec{v}||\sin\theta||\vec{B}|$$

$$\vec{F}_M = \vec{I}\ell\times\vec{B}$$

$$|\vec{F}_M| = |\vec{I}\ell||\sin\theta||\vec{B}|$$

$$\Phi_B = \vec{B}\bullet\vec{A}$$

$$\Phi_B = |\vec{B}|\cos\theta|\vec{A}|$$

$$\mathcal{E} = -\frac{\Delta\Phi_B}{\Delta t}$$

$$\mathcal{E} = B\ell v$$

FLUID MECHANICS AND THERMAL PHYSICS

$\rho = \frac{m}{V}$

$P = \frac{F}{A}$

$P = P_o + \rho g h$

$F_b = \rho V g$

$A_1 v_1 = A_2 v_2$

$P_1 + \rho g y_1 + \frac{1}{2}\rho v_1^2 = P_2 + \rho g y_2 + \frac{1}{2}\rho v_2^2$

$\frac{Q}{\Delta t} = \frac{kA\,\Delta T}{L}$

$PV = nRT = Nk_BT$

$K = \frac{3}{2}k_BT$

$W = -P\Delta V$

$\Delta U = Q + W$

- 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

MODERN PHYSICS

$E = hf$

$K_{max} = hf - \phi$

$\lambda = \frac{h}{p}$

$E = mc^2$

- E = energy
- f = frequency
- K = kinetic energy
- m = mass
- p = momentum
- λ = wavelength
- ϕ = work function

WAVES AND OPTICS

$\lambda = \frac{v}{f}$

$n = \frac{c}{v}$

$n_1 \sin\theta_1 = n_2 \sin\theta_2$

$\frac{1}{s_i} + \frac{1}{s_o} = \frac{1}{f}$

$|M| = \left|\frac{h_i}{h_o}\right| = \left|\frac{s_i}{s_o}\right|$

$\Delta L = m\lambda$

$d\sin\theta = m\lambda$

- 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

GEOMETRY AND TRIGONOMETRY

Rectangle
$A = bh$

Triangle
$A = bh$

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

Rectangular solid
$V = \ell wh$

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

Sphere
$V = \frac{4}{3}\pi r^3$
$S = 4\pi r^2$

- A = area
- C = circumference
- V = volume
- S = surface area
- b = base
- h = height
- ℓ = length
- w = width
- r = radius

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

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

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

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