REFERENCE MATERIALS FOR PHYSICS

Notes for Physics Test

Not all formulas necessary are listed, nor are all formulas listed used on this test.

In questions on electricity and magnetism, the term *current* refers to "conventional current" and the use of the right-hand rule is assumed.

While attention has been paid to significant figures, no answer should be considered incorrect solely because of the number of significant figures.

Physical Constants

Description	Symbol	Value
Acceleration due to gravity on Earth	g	9.81 m/s^2
Speed of light in a vacuum	c	3.00×10^8 m/s
Universal gravitational constant	G	6.67×10^{-11} N•m^2/kg^2
Planck's constant	h	6.63×10^{-34} J•s = 4.14×10^{-15} eV•s
Coulomb's constant	k	8.99×10^9 N•m^2/C^2
Elementary charge	e	1.60×10^{-19} C
Electron rest mass	m_e	9.11×10^{-31} kg
Proton rest mass	m_p	1.67×10^{-27} kg
Permeability of free space	μ_0	1.26×10^{-6} T•m/A
Avogadro constant	N_A	6.02×10^{23} particles/mol
Boltzmann constant	k_B	1.38×10^{-23} J/K
Gas constant	R	8.31 J/mol•K

Unit Definitions

Name	Symbol	Value
1 coulomb	C	6.25×10^{18} elementary charges
1 electronvolt	eV	1.60×10^{-19} J

Classical Mechanics Formulas

Description	Formula	Symbols
Average velocity	$\mathbf{v} = \frac{\Delta \mathbf{d}}{t}$	v = average velocity d = displacement t = time
Average acceleration	$\mathbf{a} = \frac{\Delta \mathbf{v}}{t}$	a = average acceleration
Final velocity	$v_f = v_i + at$	v_f = final velocity v_i = initial velocity
Kinematic equation	$\Delta d = v_i t + \frac{1}{2} at^2$	
Kinematic equation	$v_f^2 - v_i^2 = 2a\Delta d$	
x-component	$V_x = V(\cos \theta)$	V = vector V_x = x-component of V
y-component	$V_y = V(\sin \theta)$	V_y = y-component of V

Description	Formula	Symbols
Newton's second law	$\mathbf{a} = \frac{\mathbf{F}_{\text{net}}}{m}$	F_{net} = net force m = mass
Force of friction	$F_f = \mu F_N$	F_f = force of friction μ = coefficient of friction F_N = normal force
Newton's law of universal gravitation	$F_g = \frac{Gm_1m_2}{r^2}$	F_g = force of gravity r = distance between centers of mass
Weight	$F_g = mg$	
Centripetal acceleration	$a_c = \frac{v^2}{r}$	a_c = centripetal acceleration r = radius
Angular velocity	$\omega = \frac{v}{r}$	ω = angular velocity
Angular acceleration	$\alpha = \frac{a}{r}$	α = angular acceleration
Circular motion	$\Delta\theta = \omega_i t + \frac{1}{2}\alpha t^2$	$\Delta\theta$ = angular displacement ω_i = initial angular velocity
Circular motion	$\omega_f = \omega_i + \alpha t$	ω_f = final angular velocity
Moment of inertia	$I = \sum_i m_i r_i^2$	I = moment of inertia
Torque	$\tau = I\alpha$	τ = torque
Torque	$\boldsymbol{\tau} = \mathbf{r} \times \mathbf{F}$ $\tau = r F_{\perp} = rF(\sin\theta)$	F = force
Hooke's law	$F = -kx$	k = spring constant
Period of spring	$T = 2\pi\sqrt{\frac{m}{k}}$	T = period
Period of simple pendulum	$T = 2\pi\sqrt{\frac{\ell}{g}}$	ℓ = length

Momentum and Energy Formulas

Description	Formula	Symbols
Momentum	$\mathbf{p} = m\mathbf{v}$	p = linear momentum
Conservation of momentum	$p_f = p_i$	p_f = final momentum p_i = initial momentum
Impulse	$\mathbf{F}_{\mathbf{net}}t = \Delta\mathbf{p}$	
Elastic potential energy	$U_e = \frac{1}{2}k\Delta x^2$	U_e = elastic potential energy Δx = change in length
Gravitational potential energy	$U_g = mg\Delta h$	U_g = gravitational potential energy h = height
Kinetic energy	$KE = \frac{1}{2}mv^2$	KE = kinetic energy
Work	$W = Fd(\cos\theta)$	W = work
Work-energy principle	$W = \Delta KE$	
Work-energy principle	$W = -\Delta U$	U = potential energy
Power	$P = \frac{W}{t}$	P = power
Power	$P = \mathbf{F} \cdot \mathbf{v}$	
Angular momentum	$L = I\omega$	L = angular momentum
Angular momentum	$\mathbf{L} = \mathbf{r} \times \mathbf{p}$ $L = rmv_\perp = r_\perp mv$	

Wave Formulas

Description	Formula	Symbols
Wave speed	$v = f\lambda$	λ = wavelength f = frequency
Wave period	$T = \frac{1}{f}$	T = period
Law of reflection	$\theta_i = \theta_r$	θ_i = angle of incidence θ_r = angle of reflection
Index of refraction	$n = \frac{c}{v}$	n = index of refraction c = speed of light in a vacuum
Law of refraction	$n_1 \sin \theta_1 = n_2 \sin \theta_2$	θ_1 = angle of incidence θ_2 = angle of refraction
Law of refraction	$\frac{n_2}{n_1} = \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2}$	λ_1 = incident wavelength λ_2 = refracted wavelength
Speed of waves on a string	$v = \sqrt{\frac{F_T}{m / L}}$	F_T = tension force L = string length
Standing wave condition for a string fixed at both ends	$2L = n\lambda$ where n is an integer	
Standing wave condition for a string fixed at one end	$4L = n\lambda$ where n is an odd integer	
Standing wave condition for a tube open at both ends	$2L = n\lambda$ where n is an integer	
Standing wave condition for a tube closed at one end	$4L = n\lambda$ where n is an odd integer	
Thin lens equation	$\frac{1}{f} = \frac{1}{o} + \frac{1}{i}$	f = focal length o = object distance i = image distance

Thermodynamics Formulas

Description	Formula	Symbols
Heat formula	$Q = mc\Delta T$	Q = heat c = specific heat capacity ΔT = change in temperature
Latent heat	$Q = mL$	L = latent heat of fusion or vaporization
Equipartition	$\left[\frac{1}{2}mv^2\right]_{average} = \frac{3}{2}k_BT$	T = thermodynamic temperature
Ideal gas law	$PV = nRT$	n = number of moles P = pressure V = volume
Gas constant	$R = N_Ak_B$	
First law of thermodynamics	$\Delta U = Q - W$	ΔU = change in internal energy W = work done by system

Electricity and Magnetism Formulas

Description	Formula	Symbols
Coulomb's law	$F_e = k\frac{q_1 q_2}{r^2}$	q = charge k = Coulomb's constant
Electric field strength	$E = \frac{F_e}{q}$	E = electric field strength F_e = electrostatic force
Potential difference	$V = \frac{W}{q} = Ed$	V = potential difference W = electrical work
Current	$I = \frac{q}{t}$	I = current t = time
Ohm's law	$V = IR$	R = resistance
Electrical power	$P = IV = I^2R = \frac{V^2}{R}$	P = power
Electrical resistivity	$\rho = R\frac{A}{\ell}$	ρ = electrical resistivity A = cross-sectional area ℓ = length
Electrical power	$P = \frac{W}{t}$	

Description	Formula	Symbols
Current in series circuits	$I = I_1 = I_2 = I_3 = \ldots$	
Voltage in series circuits	$V = V_1 + V_2 + V_3 + \ldots$	
Resistance in series circuits	$R_{eq} = R_1 + R_2 + R_3 + \ldots$	
Current in parallel circuits	$I = I_1 + I_2 + I_3 + \ldots$	
Voltage in parallel circuits	$V = V_1 = V_2 = V_3 = \ldots$	
Resistance in parallel circuits	$R_{eq} = \dfrac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots}$	
Resonant frequency of an LC circuit	$f_0 = \dfrac{\omega_0}{2\pi} = \dfrac{1}{2\pi\sqrt{LC}}$	ω_0 = resonant angular frequency f_0 = resonant equivalent frequency L = inductance C = capacitance
Force on a charged particle in a magnetic field	$\mathbf{F} = q\mathbf{v} \times \mathbf{B}$ $F = qvB(\sin\theta)$	B = magnetic field strength
Force on a current-carrying wire	$\mathbf{F} = \mathbf{I}\ell \times \mathbf{B}$ $F = I\ell B(\sin\theta)$	ℓ = length
Biot-Savart law	$\mathbf{B}(\mathbf{r}) = \dfrac{\mu_0}{4\pi} \displaystyle\int_c \dfrac{Id\ell \times \mathbf{r}'}{\lvert\mathbf{r}'\rvert^3}$	$r' = r - \ell$ = displacement vector r = position
Faraday's law of induction	$EMF = -N \dfrac{\Delta B_{\perp} A}{\Delta t}$	EMF = electromotive force N = number of turns
Ideal transformer equation	$\dfrac{V_S}{V_P} = \dfrac{N_S}{N_P}$	V_S = secondary voltage V_P = primary voltage N_S = number of secondary turns N_P = number of primary turns

Modern Physics Formulas

Description	Formula	Symbols
Photon energy	$E = hf = \frac{hc}{\lambda}$	E = energy c = speed of light in vacuum
Mass-energy equivalence	$E = mc^2$	m = mass
De Broglie wavelength	$\lambda = \frac{h}{p}$	p = momentum
Photoelectric effect	$KE_{max} = hf - \varphi$ $KE_{max} = eV_0$	KE_{max} = maximum kinetic energy φ = work function V_0 = stopping potential
Lorentz factor	$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$	γ = Lorentz factor
Length contraction	$\Delta x' = \frac{\Delta x}{\gamma}$	$\Delta x'$ = length in observer's reference frame Δx = length in object's reference frame
Time dilation	$\Delta t' = \gamma \Delta t$	$\Delta t'$ = time in observer's reference frame Δt = time in object's reference frame