SAT Subject Physics Formula Reference

This guide is a compilation of about fifty of the most important physics formulas to know for the SAT Subject test in physics. (Note that formulas are *not* given on the test.) Each formula row contains a description of the variables or constants that make up the formula, along with a brief explanation of the formula.

Kinematics

$v_{\text{ave}} = \dfrac{\Delta x}{\Delta t}$	v_{ave} = average velocity Δx = displacement Δt = elapsed time	The definition of average velocity.
$v_{\text{ave}} = \dfrac{(v_{\text{i}} + v_{\text{f}})}{2}$	v_{ave} = average velocity v_{i} = initial velocity v_{f} = final velocity	Another definition of the average velocity, which works when a is constant.
$a = \dfrac{\Delta v}{\Delta t}$	a = acceleration Δv = change in velocity Δt = elapsed time	The definition of acceleration.
$\Delta x = v_{\text{i}}\Delta t + \dfrac{1}{2}a(\Delta t)^2$	Δx = displacement v_{i} = initial velocity Δt = elapsed time a = acceleration	Use this formula when you don't have v_{f}.
$\Delta x = v_{\text{f}}\Delta t - \dfrac{1}{2}a(\Delta t)^2$	Δx = displacement v_{f} = final velocity Δt = elapsed time a = acceleration	Use this formula when you don't have v_{i}.

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Kinematics (continued)

$v_f^2 = v_i^2 + 2a\Delta x$	v_f = final velocity v_i = initial velocity a = acceleration Δx = displacement	Use this formula when you don't have Δt.

Dynamics

$F = ma$	F = force m = mass a = acceleration	Newton's Second Law. Here, F is the *net* force on the mass m.
$W = mg$	W = weight m = mass g = acceleration due to gravity	The weight of an object with mass m. This is really just Newton's Second Law again.
$f = \mu N$	f = friction force μ = coefficient of friction N = normal force	The "Physics is Fun" equation. Here, μ can be either the kinetic coefficient of friction μ_k or the static coefficient of friction μ_s.
$p = mv$	p = momentum m = mass v = velocity	The definition of momentum. It is conserved (constant) if there are no external forces on a system.

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Dynamics (continued)

$\Delta p = F\Delta t$	Δp = change in momentum F = applied force Δt = elapsed time	$F\Delta t$ is called the *impulse*.

Work, Energy, and Power

$W = Fd\cos\theta$ *or* $W = F_{\parallel}d$	W = work F = force d = distance θ = angle between F and the direction of motion $F_{\parallel}$ = parallel force	Work is done when a force is applied to an object as it moves a distance d. $F_{\parallel}$ is the component of F in the direction that the object is moved.
$\text{KE} = \frac{1}{2}mv^2$	KE = kinetic energy m = mass v = velocity	The definition of kinetic energy for a mass m with velocity v.
$\text{PE} = mgh$	PE = potential energy m = mass g = acceleration due to gravity h = height	The potential energy for a mass m at a height h above some reference level.

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Work, Energy, Power (continued)

$W = \Delta(\text{KE})$	W = work done KE = kinetic energy	The "work-energy" theorem: the work done by the *net* force on an object equals the change in kinetic energy of the object.
$\text{E} = \text{KE} + \text{PE}$	E = total energy KE = kinetic energy PE = potential energy	The definition of total ("mechanical") energy. If there is no friction, it is conserved (stays constant).
$P = \dfrac{W}{\Delta t}$	P = power W = work Δt = elapsed time	Power is the amount of work done per unit time (i.e., power is the *rate* at which work is done).

Circular Motion

$a_c = \dfrac{v^2}{r}$	a_c = centripetal acceleration v = velocity r = radius	The "centripetal" acceleration for an object moving around in a circle of radius r at velocity v.
$F_c = \dfrac{mv^2}{r}$	F_c = centripetal force m = mass v = velocity r = radius	The "centripetal" force that is needed to keep an object of mass m moving around in a circle of radius r at velocity v.

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Circular Motion (continued)

$v = \frac{2\pi r}{T}$	v = velocity r = radius T = period	This formula gives the velocity v of an object moving once around a circle of radius r in time T (the period).
$f = \frac{1}{T}$	f = frequency T = period	The frequency is the number of times per second that an object moves around a circle.

Torques and Angular Momentum

$\tau = rF\sin\theta$ *or* $\tau = rF_\perp$	τ = torque r = distance (radius) F = force θ = angle between F and the lever arm $F_\perp$ = perpendicular force	Torque is a force applied at a distance r from the axis of rotation. $F_\perp = F\sin\theta$ is the component of F perpendicular to the lever arm.
$L = mvr$	L = angular momentum m = mass v = velocity r = radius	Angular momentum is conserved (i.e., it stays constant) as long as there are no external torques.

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Springs

$F_s = kx$	F_s = spring force k = spring constant x = spring stretch or compression	"Hooke's Law". The force is opposite to the stretch or compression direction.
$\text{PE}_s = \frac{1}{2}kx^2$	PE_s = potential energy k = spring constant x = amount of spring stretch or compression	The potential energy stored in a spring when it is either stretched or compressed. Here, $x = 0$ corresponds to the "natural length" of the spring.

Simple Harmonic Motion

$T_s = 2\pi\sqrt{\frac{m}{k}}$	T_s = period of motion k = spring constant m = attached mass	The period of the simple harmonic motion of a mass m attached to an ideal spring with spring constant k.
$T_p = 2\pi\sqrt{\frac{l}{g}}$	T_p = period of motion l = pendulum length g = acceleration due to gravity	The period of the simple harmonic motion of a mass m on an ideal pendulum of length l.

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Gravity

$F_g = G\frac{m_1 m_2}{r^2}$	F_g = force of gravity G = a constant m_1, m_2 = masses r = distance of separation	Newton's Law of Gravitation: this formula gives the attractive force between two masses a distance r apart.

Electric Fields and Forces

$F = k\frac{q_1 q_2}{r^2}$	F = electric force k = a constant q_1, q_2 = charges r = distance of separation	"Coulomb's Law". This formula gives the force of attraction or repulsion between two charges a distance r apart.
$F = qE$	F = electric force E = electric field q = charge	A charge q, when placed in an electric field E, will feel a force on it, given by this formula (q is sometimes called a "test" charge, since it tests the electric field strength).
$E = k\frac{q}{r^2}$	E = electric field k = a constant q = charge r = distance of separation	This formula gives the electric field due to a charge q at a distance r from the charge. Unlike the "test" charge, the charge q here is actually generating the electric field.

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Electric Fields and Forces (continued)

$U_E = k\frac{q_1 q_2}{r}$	U_E = electric PE k = a constant q_1, q_2 = charges r = distance of separation	This formula gives the electric potential energy for two charges a distance r apart. For more than one pair of charges, use this formula for each pair, then add all the U_E's.
$\Delta V = \frac{-W_E}{q} = \frac{\Delta U_E}{q}$	ΔV = potential difference W_E = work done by E field U_E = electric PE q = charge	The potential difference ΔV between two points is defined as the negative of the work done by the electric field per unit charge as charge q moves from one point to the other. Alternately, it is the change in electric potential energy per unit charge.
$V = k\frac{q}{r}$	V = electric potential k = a constant q = charge r = distance of separation	This formula gives the electric potential due to a charge q at a distance r from the charge. For more than one charge, use this formula for each charge, then add all the V's.
$E = \frac{V}{d}$	E = electric field V = voltage d = distance	Between two large plates of metal separated by a distance d which are connected to a battery of voltage V, a uniform electric field between the plates is set up, as given by this formula.

Circuits

$V = IR$	V = voltage I = current R = resistance	"Ohm's Law". This law gives the relationship between the battery voltage V, the current I, and the resistance R in a circuit.

Circuits (continued)

$P = IV$ *or* $P = V^2/R$ *or* $P = I^2R$	P = power I = current V = voltage R = resistance	All of these power formulas are equivalent and give the power used in a circuit resistor R. Use the formula that has the quantities that you know.
$R_s = R_1 + R_2 + \ldots$	R_s = total (series) resistance R_1 = first resistor R_2 = second resistor $\ldots$	When resistors are placed end to end, which is called "in series", the effective total resistance is just the sum of the individual resistances.
$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$	R_p = total (parallel) resistance R_1 = first resistor R_2 = second resistor $\ldots$	When resistors are placed side by side (or "in parallel"), the effective total resistance is the inverse of the sum of the reciprocals of the individual resistances (whew!).
$q = CV$	q = charge C = capacitance V = voltage	This formula is "Ohm's Law" for capacitors. Here, C is a number specific to the capacitor (like R for resistors), q is the charge on one side of the capacitor, and V is the voltage across the capacitor.

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Magnetic Fields and Forces

$F = ILB\sin\theta$	F = force on a wire I = current in the wire L = length of wire B = external magnetic field θ = angle between the current direction and the magnetic field	This formula gives the force on a wire carrying current I while immersed in a magnetic field B. Here, θ is the angle between the direction of the current and the direction of the magnetic field (θ is usually 90°, so that the force is $F = ILB$).
$F = qvB\sin\theta$	F = force on a charge q = charge v = velocity of the charge B = external magnetic field θ = angle between the direction of motion and the magnetic field	The force on a charge q as it travels with velocity v through a magnetic field B is given by this formula. Here, θ is the angle between the direction of the charge's velocity and the direction of the magnetic field (θ is usually 90°, so that the force is $F = qvB$).

Waves and Optics

$v = \lambda f$	v = wave velocity λ = wavelength f = frequency	This formula relates the wavelength and the frequency of a wave to its speed. The formula works for both sound and light waves.
$v = \frac{c}{n}$	v = velocity of light c = vacuum light speed n = index of refraction	When light travels through a medium (say, glass), it slows down. This formula gives the speed of light in a medium that has an index of refraction n. Here, $c = 3.0 \times 10^8$ m/s.

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Waves and Optics (continued)

$n_1 \sin\theta_1 = n_2 \sin\theta_2$	n_1 = incident index θ_1 = incident angle n_2 = refracted index θ_2 = refracted angle	"Snell's Law". When light moves from one medium (say, air) to another (say, glass) with a different index of refraction n, it changes direction (refracts). The angles are taken from the normal (perpendicular).
$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$	d_o = object distance d_i = image distance f = focal length	This formula works for lenses and mirrors, and relates the focal length, object distance, and image distance.
$m = -\frac{d_i}{d_o}$	m = magnification d_i = image distance d_o = object distance	The magnification m is how much bigger ($\|m\| > 1$) or smaller ($\|m\| < 1$) the image is compared to the object. If $m < 0$, the image is inverted compared to the object.

Heat and Thermodynamics

$Q = mc\Delta T$	Q = heat added or removed m = mass of substance c = specific heat ΔT = change in temperature	The specific heat c for a substance gives the heat needed to raise the temperature of a mass m of that substance by ΔT degrees. If $\Delta T < 0$, the formula gives the heat that has to be *removed* to lower the temperature.

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Heat and Thermodynamics (continued)

$Q = ml$	Q = heat added or removed m = mass of substance l = specific heat of transformation	When a substance undergoes a change of phase (for example, when ice melts), the temperature doesn't change; however, heat has to be added (ice melting) or removed (water freezing). The specific heat of transformation l is different for each substance.
$\Delta U = Q - W$	ΔU = change in internal energy Q = heat added W = work done by the system	The "first law of thermodynamics". The change in internal energy of a system is the heat added minus the work done by the system.
$E_{\text{eng}} = \frac{W}{Q_{\text{hot}}} \times 100$	E_{eng} = % efficiency of the heat engine W = work done by the engine Q_{hot} = heat absorbed by the engine	A heat engine essentially converts heat into work. The engine does work by absorbing heat from a hot reservoir and discarding some heat to a cold reservoir. The formula gives the quality ("efficiency") of the engine.

Pressure and Gases

$P = \frac{F}{A}$	P = pressure F = force A = area	The definition of pressure. P is a force per unit area exerted by a gas or fluid on the walls of the container.

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Pressure and Gases (continued)

$\frac{PV}{T} = \text{constant}$	P = pressure V = volume T = temperature	The "Ideal Gas Law". For "ideal" gases (and also for real-life gases at low pressure), the pressure of the gas times the volume of the gas divided by the temperature of the gas is a constant.

Modern Physics and Relativity

$E = hf$	E = photon energy h = a constant f = wave frequency	The energy of a photon is proportional to its wave frequency; h is a number called "Planck's constant".
$\text{KE}_{\text{max}} = hf - \phi$	KE_{max} = max kinetic energy h = a constant f = light frequency ϕ = work function of the metal	The "photoelectric effect" formula. If light of frequency f is shined on a metal with "work function" ϕ, and $hf > \phi$, then electrons are emitted from the metal. The electrons have kinetic energies no greater than KE_{max}.
$\lambda = \frac{h}{p}$	λ = matter wavelength h = a constant p = momentum	A particle can act like a wave with wavelength λ, as given by this formula, if it has momentum p. This is called "wave-particle" duality.
$\gamma = \frac{1}{\sqrt{1-(v/c)^2}}$	γ = the relativistic factor v = speed of moving observer c = speed of light	The relativistic factor γ is the amount by which moving clocks slow down and lengths contract, as seen by an observer compared to those of another observer moving at speed v (note that $\gamma \geq 1$).