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}.

Kinematics (continued)

$v_\text{f}^2 = v_\text{i}^2 + 2a\Delta x$	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.

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.

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.

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.

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

$F_g = G\dfrac{m_1 m_2}{r^2}$	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

$F = k\dfrac{q_1 q_2}{r^2}$	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).
$E = k\dfrac{q}{r^2}$	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.

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.
$\Delta V = \frac{-W_E}{q} = \frac{\Delta U_E}{q}$	$\Delta V =$ 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 ...	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 ...	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.

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.
$v = \dfrac{c}{n}$	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.

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.

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.
$E_{\text{eng}} = \dfrac{W}{Q_{\text{hot}}} \times 100$	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

$P = \dfrac{F}{A}$	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.

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 $\gamma \geq 1$).