NCSSM Physics Reference Sheet

Updated August 2024 (version 5)

Fundamental Physics Principles

$$\sum W_{\text{external}} = \Delta E_{\text{system}} \qquad \sum F_{\text{external}} = m a_{\text{system}} \qquad \sum J_{\text{external}} = \Delta p_{\text{system}}$$

Energy

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

$$U_{\text{gravitational}} = mgy \quad (+y \text{ is up})$$

$$U_{\text{point masses}} = -G\frac{m_1 m_2}{r}$$

$$\Delta E_{\text{thermal}} = |\Delta x|\,|F_{\text{kinetic friction}}|$$

$$U_{\text{elastic/spring}} = \frac{1}{2}k\Delta l^2$$

$$U_{\text{electric}} = qV$$

$$|\Delta V| = |E|\,|\Delta s|$$

$$E_{\text{photon}} = hf$$

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

Circular Motion

$$|a| = \frac{v^2}{r} \qquad v = \frac{2\pi r}{T}$$

Forces

$$F_{\substack{\text{interaction type,}\\ \text{on system}\\ \text{by external object, field, etc.}}}$$

$$|F_{\text{gravitational field}}| = mg$$

$$|F_{\text{kinetic friction}}| = \mu_k\,|F_N|$$

$$|F_{\text{static friction}}| \le \mu_s\,|F_N|$$

$$|F_{\text{elastic/spring}}| = k\,|\Delta l|$$

$$|F_{\text{point masses}}| = G\frac{m_1 m_2}{r^2}$$

$$|F_{\text{point charges}}| = k_{\text{elec}}\frac{|q_1|\,|q_2|}{r^2}$$

$$|F_{\text{electric field}}| = |q|\,|E|$$

$$|F_{\text{magnetic field}}| = |q|\,|v|\,|B|\sin\theta_{vB}$$

$$|F_{B \text{ on wire}}| = |B|\,|I|\,l\sin\theta_{IB}$$

Momentum

$$p = mv$$

Constants and Accepted Values

$$g = 9.8\ \text{m/s}^2 = 9.8\ \text{N/kg}$$

$$G = 6.7\times10^{-11}\ \text{N}\cdot\text{m}^2/\text{kg}^2$$

$$k_{\text{elec}} = 9.0\times10^{9}\ \text{N}\cdot\text{m}^2/\text{C}^2$$

$$c = 3.0\times10^{8}\ \text{m/s}$$

$$h = 6.6\times10^{-34}\ \text{J}\cdot\text{s}$$

$$m_{\text{Earth}} = 6.0\times10^{24}\ \text{kg}$$

$$m_{\text{Sun}} = 2.0\times10^{30}\ \text{kg}$$

$$r_{\text{Earth}} = 6.4\times10^{6}\ \text{m}$$

$$v_{\text{sound}} = 340\ \text{m/s} \quad (\text{in air at STP})$$

$$m_{\text{electron}} = 9.1\times10^{-31}\ \text{kg}$$

$$m_{\text{proton}} = 1\ \text{amu} = 1.7\times10^{-27}\ \text{kg}$$

$$q_{\text{electron}} = -1.6\times10^{-19}\ \text{C}$$

$$q_{\text{proton}} = 1.6\times10^{-19}\ \text{C}$$

$$1\ \text{eV} = 1.6\times10^{-19}\ \text{J}$$

Connecting Forces, Energy, and Momentum

$$W = |F_{\text{avg}}|\,|\Delta x|\cos\theta_{F\Delta x} = \text{area under } F\text{-}x \text{ graph}$$

$$J = F_{\text{avg}}\,\Delta t = \text{area under } F\text{-}t \text{ graph}$$

Constant Acceleration Kinematics (DVAT)

$$a = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t_f - t_i}$$

$$\Delta x = v_i\,\Delta t + \frac{1}{2}a\,\Delta t^2$$

$$v_f^2 = v_i^2 + 2a\,\Delta x$$

$$\Delta x = \frac{v_i + v_f}{2}\,\Delta t$$

$$\Delta x = \text{area under } v\text{-}t \text{ graph}$$

Problem Solving

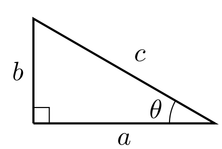
Diagram(s)
Knowns and unknowns
Principle and system
Symbolic solution
Check answer (sign, units, sensible)
Cite sources

Quadratic Formula

If $Ax^2 + Bx + C = 0$,

$$x = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A}.$$

Trigonometry



$$\sin\theta = \text{opp/hyp} = b/c$$
$$\cos\theta = \text{adj/hyp} = a/c$$
$$\tan\theta = \text{opp/adj} = b/a$$

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

Is your calculator in degrees or radians?

SI Base Units

kg m s C K

SI Derived Units

$\text{N} = \text{kg}\cdot\text{m/s}^2$	$\text{A} = \text{C/s}$
$\text{J} = \text{N}\cdot\text{m}$	$\text{V} = \text{J/C}$
$\text{W} = \text{J/s}$	$\Omega = \text{V/A}$
$\text{Hz} = 1/\text{s}$	$\text{T} = \text{N}\cdot\text{s}/(\text{C}\cdot\text{m})$

SI Prefixes

$\text{G} = 10^{9}$	giga
$\text{M} = 10^{6}$	mega
$\text{k} = 10^{3}$	kilo
$\text{c} = 10^{-2}$	centi
$\text{m} = 10^{-3}$	milli
$\mu = 10^{-6}$	micro
$\text{n} = 10^{-9}$	nano

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NCSSM Physics Honesty Policy

All work shown on this assessment is my own. I have neither given nor received any unauthorized assistance with this assessment. I will not discuss this assessment with anyone until my teacher tells me it is acceptable to do so.

Circuits

$$|\Delta V| = |I|\, R$$

$$0 = \sum_{\text{loop}} \Delta V$$

$$\sum_{\text{in}} I = \sum_{\text{out}} I$$

$$R_{\text{series}} = R_1 + R_2 + \cdots$$

$$\frac{1}{R_{\text{parallel}}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots$$

$$|P| = |I|\, |\Delta V|$$

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

A	area
ρ	resistivity

Light and Optics

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

$$n_i \sin\theta_i = n_t \sin\theta_t$$

$$\frac{1}{f} = \frac{1}{s} + \frac{1}{s'}$$

$$M = \frac{-s'}{s} = \frac{h'}{h}$$

$$\Delta r = m\lambda \quad \text{(constructive)}$$

$$\Delta r = \left(m + \frac{1}{2}\right)\lambda \quad \text{(destructive)}$$

$$d\sin\theta = m\lambda \quad \text{(constructive)}$$

$$d\sin\theta = \left(m + \frac{1}{2}\right)\lambda \quad \text{(destructive)}$$

$$d\,\frac{y}{L} \approx m\lambda \quad (\text{constructive, } \theta < 1^\circ)$$

d	slit distance
f	focal length
h	height
L	screen distance
m	fringe number
M	magnification
n	index of refraction
r	path length
y	fringe position (center = 0)

Waves and Oscillations

$$x(t) = A\sin\left(\tfrac{2\pi}{T}\,t + \phi\right) + x_{\text{equilibrium}}$$

or

$$x(t) = A\cos\left(\tfrac{2\pi}{T}\,t + \phi\right) + x_{\text{equilibrium}}$$

(must use radians)

$$T_{\text{mass on spring}} = 2\pi\sqrt{\frac{m}{k}}$$

$$v_{\text{wave on string}} = \sqrt{\frac{F_{\text{tension}}}{\mu}}$$

$$y(x,t) = A\sin\left(\frac{2\pi x}{\lambda} \pm \frac{2\pi t}{T}\right)$$

$$f = 1/T$$

$$v = f\lambda$$

$$f_{\text{beat}} = |f_1 - f_2|$$

$$\mu = m/l$$

y	displacement
μ	linear density
ϕ	initial phase

Astrophysics

$$\lambda_{\text{brightest}} = \frac{b_{\text{Wien}}}{T}$$

$$\frac{1}{\lambda_{\text{H,emit}}} = R_{\text{Ryd}}\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

$$\frac{v}{c} = \frac{\lambda_{\text{observe}} - \lambda_{\text{emit}}}{\lambda_{\text{emit}}}$$

$$b_{\text{Wien}} = 0.0029\ \text{m}\cdot\text{K}$$

$$R_{\text{Ryd}} = 1.1 \times 10^{7}/\text{m}$$

$$L_{\text{Sun}} = 3.8 \times 10^{26}\ \text{W}$$

$$1\ \text{AU} = 1.5 \times 10^{11}\ \text{m}$$

n	orbital number
T	temperature

Symbols

These are general usage; see other boxes for area-specific usage.

a	acceleration
A	amplitude
B	magnetic field
E	energy OR electric field
f	frequency
F	force
I	current
J	impulse
k	spring constant
K	kinetic energy
l	length
m	mass
p	momentum
P	power
q	electric charge
r	radius OR separation
R	resistance
s	distance
t	time
T	period
U	energy
v	velocity OR speed
V	electric potential (voltage)
W	work
x	position
Δ	difference OR change
θ	angle
λ	wavelength
μ	coefficient of friction

About this Reference

This reference is meant to reduce the need to memorize, but knowing what an equation means and how to use it are still up to you. Some of these equations may be unfamiliar because your class doesn't use them; if you do not recognize an equation, chances are you should not be using it. Notation is not always standardized, between this reference and other sources or between different teachers and classes at NCSSM.