Equation Sheet For Quizzes and Tests

You must have memorized the unit prefix values and the formulas related to circles and rectangles.

Chapter 1:

$$\text{density} = \frac{\text{mass}}{\text{volume}} \qquad \rho = \frac{m}{V}$$

Aluminum	2.70	g/cm^3	Lead	11.34	g/cm^3	Gasoline	0.680	g/cm^3
Iron	7.87	g/cm^3	Mercury	13.6	g/cm^3	Water	1.00	g/cm^3
Copper	8.96	g/cm^3	Uranium	19.1	g/cm^3	Seawater	1.03	g/cm^3

Chapter 2:

$$\text{velocity} = \text{speed } \textbf{and} \text{ direction} \qquad \text{average velocity} = \frac{\text{change in position}}{\text{change in time}} \qquad \bar{v} = \frac{\Delta x}{\Delta t} \quad (\text{unit: } \; m/s = \frac{m}{s})$$

$$\text{average acceleration} = \frac{\text{change of velocity}}{\text{time}} \qquad \bar{a} = \frac{\Delta v}{\Delta t} \quad \text{acceleration has direction} \quad (\text{unit: } \; m/s^2 = \frac{m}{s^2})$$

Assuming no acceleration, constant velocity, and initial position=0:

$$\text{distance} = (\text{velocity}) \cdot (\text{time}) \qquad d = v\,t$$

Assuming constant acceleration, initial velocity=0 and initial position= 0:

$$\text{velocity} = (\text{acceleration}) \cdot (\text{time}) \qquad v = a\,t \qquad \text{distance} = \frac{1}{2}(\text{acceleration}) \cdot (\text{time})^2 \qquad d = \frac{1}{2} a\,t^2$$

$$\text{net force} = (\text{mass}) \cdot (\text{acceleration}) \qquad F_{\text{net}} = m\,a \quad \text{force has direction} \quad \text{unit: } \; \text{newton}, \; N = \frac{kg \cdot m}{s^2}$$

Weight is the downward force caused by gravity:

$$\text{weight} = (\text{mass}) \cdot (\text{acceleration due to gravity}) \qquad w = m\,g \qquad g = 9.80\,m/s^2 \; \text{ at earth surface}$$

$$\text{force on object A due to object B} = -\text{force on object B due to object A} \qquad F_{\text{A due to B}} = -F_{\text{B due to A}}$$

Momentum:

$$\text{momentum} = (\text{mass}) \cdot (\text{velocity}) \qquad p = m\,v \quad \text{momentum has direction}$$

$$\text{change of momentum} = (\text{average force}) \cdot (\text{time of interaction}) \qquad \Delta p = \bar{F}\,\Delta t$$

$$\text{conservation of total momentum in an isolated system: } \quad p_{\text{total, before}} = p_{\text{total, after}}$$

Circular motion:

$$\text{centripetal acceleration} = \frac{(\text{velocity})^2}{\text{radius of circle}} \qquad a_c = \frac{v^2}{r} \qquad \text{centripetal force} = \frac{(\text{mass}) \cdot (\text{velocity})^2}{\text{radius of circle}} \qquad F_c = m\,a_c = \frac{m\,v^2}{r}$$

Newton’s Gravitational force Law:

$$\text{gravitational force} = (\text{constant}) \cdot \frac{(\text{one mass}) \cdot (\text{another mass})}{(\text{distance})^2} \qquad F = G\frac{m_1 m_2}{d^2} \qquad G = 6.67 \times 10^{-11} \frac{N \cdot m^2}{kg^2}$$

$$\text{gravitational acceleration} = \frac{(\text{constant}) \cdot (\text{mass})}{\text{distance}^2} \qquad g = G\frac{m}{d^2}$$

Chapter 3:

Assuming constant force:

$$\text{work done by force} = (\text{force})\cdot(\text{distance moved in direction of force}) \qquad W = F\,d$$

$$\text{work unit: joule, } \mathrm{J} = \mathrm{N\cdot m} = \frac{\mathrm{kg\cdot m^2}}{\mathrm{s^2}}$$

$$\text{power} = \frac{\text{work}}{\text{time}} \qquad P = \frac{W}{t} \qquad \text{power unit: watt, } \mathrm{W} = \mathrm{J/s} = \frac{\mathrm{J}}{\mathrm{s}}$$

$$\text{change in gravitational potential energy} = \text{work} = (\text{weight})\cdot(\text{change in height}) \qquad PE = W = Fd = (m\,g)\cdot h = mgh$$

$$\text{kinetic energy} = \frac{1}{2}(\text{mass})\cdot(\text{velocity})^2 \qquad KE = \frac{1}{2}m\,v^2$$

If friction can be ignored, total mechanical energy is unchanged during free fall from height *h*:

$$\text{change in KE = change in PE} \qquad \frac{1}{2}m\,v^2 = m\,g\,h \quad \text{so} \quad v = \sqrt{(2\,g\,h)}$$

Chapter 4:

$$T_F = \frac{9}{5}T_C + 32\,^{\mathrm{o}}\mathrm{F} \qquad T_C = \frac{5}{9}(T_F - 32\,^{\mathrm{o}}\mathrm{F}) \qquad T_{\mathrm{K}} = T_{\mathrm{C}} + 273\,^{\mathrm{o}}\mathrm{C} = T_{\mathrm{C}} + 273\,\mathrm{K} \qquad \Delta T_C = \Delta T_K$$

$$\text{change in heat energy of } \mathrm{H_2O} = (\text{mass})\cdot(\text{specific heat})\cdot(\text{change in temperature}) \qquad Q = m\,c\,\Delta T$$

$$c_{ice} = 0.50\,\frac{\mathrm{cal}}{\mathrm{g\cdot{}^oC}} \qquad c_{water} = 1.00\,\frac{\mathrm{cal}}{\mathrm{g\cdot{}^oC}} \qquad c_{steam} = 0.48\,\frac{\mathrm{cal}}{\mathrm{g\cdot{}^oC}}$$

$$\mathrm{H_2O}\text{ fusion heat energy absorbed or released} = (\text{mass})\cdot(\text{latent heat of } \mathrm{H_2O}\text{ fusion})$$

$$Q = m\,L_f \qquad L_f = 80\,\frac{\mathrm{cal}}{\mathrm{g}}$$

$$\mathrm{H_2O}\text{ vaporization heat energy absorbed or released} = (\text{mass})\cdot(\text{latent heat of } \mathrm{H_2O}\text{ vaporization})$$

$$Q = m\,L_v \qquad L_v = 540\,\frac{\mathrm{cal}}{\mathrm{g}}$$

Heat and mechanical energy conversion:

$$1\text{ food calorie} = 1000\,\mathrm{cal} \qquad 1\,\mathrm{cal} = 4.186\,\mathrm{J}$$

Chapter 5:

$$\text{period} = \frac{1}{\text{frequency}} \qquad T = \frac{1}{f} \qquad \text{speed} = (\text{wavelength})\cdot(\text{frequency}) \qquad v = \lambda\,f \quad \text{or} \quad c = \lambda\,f$$

$$\text{speed of sound } v \text{ at temperature } T_C \text{ is } v = 331\,\mathrm{m/s} + \left(0.600\,\frac{\mathrm{m}}{\mathrm{s\cdot{}^oC}}\right)\cdot T_{\mathrm{C}}$$

$$\text{speed of light in vacuum} = c = 299792458\,\mathrm{m/s} \qquad (\text{Using } c = 3.00\times10^8\,\mathrm{m/s} \text{ is nearly always OK.})$$

$$\text{beat frequency = absolute value of } (\text{one frequency} - \text{other frequency}) \qquad f_{\mathrm{beat}} = |f_2 - f_1|$$

$$\text{sound intensity} = \frac{\text{sound power}}{\text{area}} \qquad I = \frac{P}{A}$$

$$\text{resonant frequency of a string or an open pipe} = \frac{(\text{an integer})\cdot(\text{velocity of wave})}{2\cdot(\text{length})} \qquad f_n = \frac{n\,v}{2\,L} \qquad n = 1, 2, 3, \ldots$$

$$\text{resonant frequency of pipe with closed end} = \frac{(\text{an odd integer})\cdot(\text{velocity of wave})}{4\cdot(\text{length})} \qquad f_n = \frac{n\,v}{4\,L} \qquad n = 1, 3, 5, \ldots$$

Chapter 6:

$$\text{quantity of charge} = (\text{number of electrons})\cdot(\text{electron charge}) \qquad q = ne = n\cdot(-1.60\times10^{-19}\,\text{C})$$ unit: coulomb, C

Coulomb’s Law:

$$\text{electrical force} = (\text{constant})\left(\frac{(\text{charge on object 1})\cdot(\text{charge on object 2})}{(\text{distance between objects})^2}\right) \qquad F = k\frac{q_1 q_2}{d^2} \qquad k = 9.00\times10^9\,\frac{\text{N}\cdot\text{m}^2}{\text{C}^2}$$

$$\text{electric potential difference} = \frac{\text{work to create potential difference}}{\text{charge moved}} \qquad V = \frac{W}{q}$$ unit: volt, $V = \frac{N}{C}$

$$\text{electric current} = \frac{\text{quantity of charge moved}}{\text{time for the movement}} \qquad I = \frac{q}{t}$$ unit: ampere, $A = \frac{C}{s}$

Ohm’s Law:

$$\text{resistance} = \frac{\text{electric potential}}{\text{electric current}} \qquad R = \frac{V}{I}$$ unit: ohm, $\Omega = \frac{V}{A}$

$$\text{electric power consumed} = (\text{electric current})\cdot(\text{electric potential}) \qquad P = IV$$ unit: watt, $\text{W} = \text{J/s} = \frac{\text{J}}{\text{s}}$

$$\text{electric cost} = \frac{(\text{electric power in W})\cdot(\text{time in h})\cdot(\text{rate in \$/kW-h})}{1000\,W/kW}$$

Ideal Transformer:

$$\frac{(\text{primary voltage})}{(\text{primary loops})} = \frac{(\text{secondary voltage})}{(\text{secondary loops})} \qquad \frac{V_p}{N_p} = \frac{V_s}{N_s}$$ (power in) = (power out) $P_{\text{in}} = P_{\text{out}}$

$$(\text{primary voltage})\cdot(\text{primary current}) = (\text{secondary voltage})\cdot(\text{secondary current}) \qquad V_p I_p = V_s I_s$$

$R_{\text{total}} = R_1 + R_2 + R_3 + \ldots$ Resistances in series $\qquad \frac{1}{R_{\text{total}}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$ Resistances in parallel

Chapter 7:

$\text{speed of light in vacuum} = c = 299792458\,\text{m/s} \approx 3.00\times10^8\,\text{m/s}$ (Using $3.00\times10^8\,\text{m/s}$ is nearly always OK.)

$$\text{period} = \frac{1}{\text{frequency}} \qquad T = \frac{1}{f} \qquad\qquad \text{speed of light in vacuum} = (\text{wavelength})\cdot(\text{frequency}) \qquad c = \lambda f$$

$$\text{angle of incidence} = \text{angle of reflection} \qquad \theta_i = \theta_r \qquad\qquad \text{index of refraction} = \frac{\text{speed of light in vacuum}}{\text{speed of light in material}} \qquad n = \frac{c}{v}$$

$$\text{energy of photon} = (\text{Planck's constant})\cdot(\text{photon frequency}) \qquad E_{\text{photon}} = hf_{\text{photon}} = (6.63\times10^{-34}\,\text{J}\cdot\text{s})f_{\text{photon}}$$

$$\text{Planck's constant} = h = 6.63\times10^{-34}\,\text{J}\cdot\text{s} \qquad \text{momentum of a photon} = \frac{\text{photon energy}}{\text{speed of light}} \qquad p_{\text{photon}} = \frac{E_{\text{photon}}}{c} = \frac{h}{\lambda_{\text{photon}}}$$

Chapter 8:

Hydrogen atom energies:

$$\frac{1}{\text{wavelength}} = (\text{constant})\left(\frac{1}{2^2} - \frac{1}{(\text{number})^2}\right) \qquad \frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{n^2}\right) = \left(1.097\times 10^7 \frac{1}{\text{m}}\right)\cdot\left(\frac{1}{2^2} - \frac{1}{n^2}\right)$$

Common energy unit used in atomic and nuclear physics: $1\,\text{eV} = 1.60\times 10^{-19}\,\text{J}$

$$\text{energy of } n^{th} \text{ orbit state} = \frac{\text{energy of innermost orbit state}}{\text{number squared}} \qquad E_n = \frac{E_1}{n^2} = -\frac{13.6\,\text{eV}}{n^2} = -\frac{2.18\times 10^{-18}\,\text{J}}{n^2} \quad \text{n=1, 2, 3, …}$$

Wavelength of massive particles:

$$\text{wavelength of massive particle} = \frac{\text{Planck's constant}}{\text{particle momentum}} = \frac{\text{Planck's constant}}{(\text{mass})\cdot(\text{velocity})} \qquad \lambda = \frac{h}{mv}$$

Chapter 9: (no equations)

Chapter 10:

$$\text{atomic weight of element} = \text{Periodic Table value with units of g/mol}$$

$$\text{formula mass of compound} = \text{sum of atomic masses of atoms in the compound with units of g/mol}$$

$$\text{moles of an element} = \frac{\text{mass in g}}{\text{atomic mass in g/mol}} \qquad \text{moles of compound} = \frac{\text{mass in g}}{\text{formula mass in g/mol}}$$

$$\text{Avogadro's number} = 6.02\times 10^{23} \text{ atoms or molecules per mol}$$

$$\frac{\text{atomic mass of element}}{\text{formula mass of compound}}\cdot(\text{number of atoms of element})\times 100 = \%\text{ of element in compound}$$

Chapter 11:

Concentration by volume: $\%\text{solute} = \frac{V_{\text{solute}}}{V_{\text{solvent}}}\times 100$ By mass: $\%\text{solute} = \frac{m_{\text{solute}}}{m_{\text{solvent}}}\times 100$

$$\text{molarity } M = \frac{\text{number of moles}}{1\,\text{L of water}} \qquad \text{unit: M, mol/L} = \frac{\text{mol}}{\text{L}} \qquad \text{pH} = -\log_{10}[H_3O^+] \qquad [H_3O^+] = 10^{-\text{pH}}$$

$[H_3O^+]$ is the concentration of H_3O^+ (or equivalently H^+) in mol/L units.

Chapter 12: (no equations)

Chapter 13:

$$\text{energy} = (\text{mass})\cdot(\text{speed of light})^2 \qquad E = mc^2$$

Symbols and Units

English letters symbols (Usually shown italicized):

x*, *y*, and *z	**mainly used for position**
r	**used for radial distance**
d	**used for linear distance**
l	**used for length**
w	**used for width and for weight**
h	**used for height**
s	**used for speed**
c	**used for the speed of light = 299792458 m/s exactly, approximate value 3.00×10^{8} m/s**
c	**specific heat in J/kg·K=J/kg·°C**
v	**used for velocity = speed with direction**
$\bar{v}$	**average velocity**
a	**used for acceleration**
$\bar{a}$	**average acceleration**
g	**used for gravitational acceleration (at the earth surface g= 9.8 m/s^2)**
G	**used for the universal gravitation constant = 6.674×10^{-11} $N\cdot m^2/kg^2$**
A	**used for area**
V	**used for volume and used for electrical potential (voltage)**
I	**used for electric current and for intensity (power per unit area) of sound or light**
R	**used for electrical resistance, the universal gas constant=8.31 J/mol·K and the Rydberg constant=1.097×10^{7} m^{-1}**
k_B	used for Boltzmann's constant=gas constant/N_A=R/N_A=1.38×10^{-23} J/K
k	**coefficient in Coulomb's law=9.00×10^{7} $N\cdot m^2/C^2$**
F	**used for force**
N	used for normal (perpendicular) force
N_p, N_s	**used for primary and secondary turn count in a transformer**
V_p, V_s	**used for primary and secondary voltages in a transformer**
n	**used for number of electrons and for the index of refraction of an optical medium**
m	**used for mass**
W	**used for work**
E	**used for energy** and also for electric field
KE	**kinetic energy**
PE	**potential energy**
U	**internal energy**
Q	**used for heat energy, usually measured in calories (cal)**
J	**conversion factor for calories to joules=4.186 J/cal (used in text, but can be confusing)**
P	**used for power (energy per unit time)**
p	**used for pressure (force per unit area)**
B	used for magnetic field
T	**used for temperature and period of cyclic motion**
h	**used for Planck's constant=6.63×10^{-34} J·s**
f	**used for frequency**
q	**used for electric charge**
C	used for electrical capacitance
L	used for electrical inductance
L_f, L_v	**used for heat of fusion (melting), and heat of vaporization (condensing)**
N_A	**used for Avogadro's constant=6.02×10^{23} *number of atoms/mol* or *molecules/mol***
e	**used for the magnitude of electron charge=1.60×10^{-19} C** and base of natural logarithms=2.71827...

Units (NOT italicized, these are easily confused with some of the quantity symbols given above):

Unit	Symbol	Quantity
meters	**m**	**distance**
gram	**g**	**mass**
second	**s**	**time**
newton	**$N=kg\cdot m/s^2$**	**force**
joule	**$J=N\cdot m=kg\cdot m^2/s^2$**	**energy, work**
watt	**W=J/s**	**power, energy per unit time**
coulomb	**C**	**electric charge**
celsius	**^oC**	**temperature measured from freezing point of water**
kelvin	**K**	**temperature measured from absolute zero**
ampere	**A=C/s**	**electric current, charge per unit time**
volt	**V=J/C**	**electric voltage**
farad	F=C/V	electrical capacitance
henry	H	electrical inductance
ohm	**Ω=V/A**	**electrical resistance**
tesla	T	magnetic field
hertz	**Hz=1/s**	**frequency, cycles per second**
radian	rad	angular measure, full circle has 2π radians
pascal	**$Pa=N/m^2$**	**pressure**
mole	**mol**	**N_A atoms or molecules**

Greek letter symbols:

pi π	**3.14159265...= circumference of a circle divided by its diameter**
rho *ρ*	**used for density and resistivity**
alpha *α*, beta *β*, theta *θ*, and phi *φ*	mainly used for angles
alpha *α*, beta *β*, and gamma *γ*	**used for different kinds of radioactivity**
sigma *σ*	used for standard deviation, uncertainty
capital sigma *Σ*	used to show summation
omega *ω*	used for angular frequency
capital omega *Ω*	used for the unit of electrical resistance
epsilon *ε* and delta *δ*	used for small changes
capital delta *Δ*	used for large changes
mu *μ*	used for coefficient of friction, prefix for micro (10^{-6})
mu naught μ_0	permeability of free space=$4\pi\times10^{-7}$ H/m
epsilon naught ε_0	permittivity of free space=8.854×10^{-12} F/m
lambda *λ*	**used for wavelength**