Simple harmonic motion and wave motion

$T = 1/f$ $v = \lambda f$ $f_n = \frac{nv}{2L}$ *nodes at both ends*

$T_{sp} = 2\pi\sqrt{\frac{m}{k}}$ $T_p = 2\pi\sqrt{\frac{L}{g}}$ $f_n = \frac{nv}{4L}$ *(n is odd) node at one end*

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

v_{sound} = 343 m/s (in air at 20 C)
A note: 440 Hz
C note: 524 Hz
D note: 588 Hz
E note: 660 Hz
G note: 784 Hz

Fluids and Thermodynamics

$^3/_2 kT = \langle ½ mv^2 \rangle_{avg}$
$P = F / A$
$P = P_0 + \rho gh$
$\Delta P + \Delta(\rho gh) + \Delta(½ \rho v^2) = 0$
$\Phi = \mathbf{A} \cdot \mathbf{v}$
$^oC = {}^oK + 273.15$

$PV = NkT = nRT$
$\mathbf{F}_{buoy} = -(\rho_{water} V_{displaced})\mathbf{g}$
$Q_{in} = W + \Delta U + Q_{out}$
$W = P\Delta V$
$k = ½\rho v^2$; $u = \rho gh$
$\eta = W/Q_{in}$; $\eta_{Carnot} = 1 - (T_{low} / T_{high})$

$k = 1.381 \times 10^{-23}$ J/K
$\rho_{air} = 1.29$ kg/m^3
R = 8.315 J/mol-K
$\rho_{water} = 1000$ kg/m^3
$P_{ATMOSPH}$ = 101,000 N/M²
$N_{avo} = 6.022 \times 10^{23}$ mol^{-1}

Properties of fundamental particles

$m_{proton} = 1.6726 \times 10^{-27}$ kg
$q_{electron} = -q_{proton} = -1.602 \times 10^{-19}$ C
$r_{hydrogen\ atom} \approx 0.529 \times 10^{-10}$ m

$m_{electron} = 9.109 \times 10^{-31}$ kg
1 amu = 1.6605×10^{-27} kg = 931.5 Mev/c²
$\Delta E = \Delta mc^2$

$m_{neutron} = 1.6749 \times 10^{-27}$ kg

Radioactivity, Nuclear Physics, and Quantum Mechanics

$(\Delta x)(\Delta p) \approx h/4\pi$
$\lambda = h/p$
$N = N_0 (½)^{t/t_H}$
1ev → 1240 nm
(energy of a photon)

$(\Delta E)(\Delta t) \approx h/4\pi$
$E_{photon} = hf = pc$
$K_{max} = qV = hf + \Phi$

$h = 6.626 \times 10^{-34}$ J·s
^AZ = element Z with A nucleons
^{14}C: t_H = 5,730 years (half life = t_h)
^{239}Pu: t_H = 24,119 years
$E_o = -13.605$ ev (Hydrogen ground state)

Light

$\lambda_{blue} \approx 450$ nm
$\lambda_{green} \approx 500$ nm
$\lambda_{red} \approx 600$ nm

$n_i \sin(\theta_i) = n_r \sin(\theta_r)$
$c = 2.998 \times 10^8$ m/s
$m\lambda = d\sin(\theta)$

$n_{air} \approx n_{vacuum} = 1.00$
$n_{water} = 1.33$
$n = c/v_{material}$

primary: Red, Green, Blue
secondary: Magenta, Cyan, Yellow
$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$ $M = h_i/h_o = d_i/d_o$

Electricity and magnetism

$\mathbf{F}_E = k q_1 q_2 / r^2$
$\mathbf{E} = \mathbf{F}_E / q$
$\mathbf{E} = -\Delta V / \Delta x$
$U_{el} = q\Delta V$

$\mathbf{F}_B = q\mathbf{v} \times \mathbf{B} = qvB\sin(\theta)$ (direction: RHR)
$\mathbf{B}_{wire} = \mu_o I / 2\pi r$ (direction: RHR)
$\mathbf{F}_{wire} = \ell(\mathbf{I} \times \mathbf{B}) = \ell IB\sin(\theta)$ (direction: RHR)
for point charges only, $E(r) = k q / r^2$ and $V(r) = k q / r$
($k = 1/4\pi\varepsilon_o$ where $\varepsilon_o = 8.854 \times 10^{-12}$ C^2/N•m^2)

$k = 8.992 \times 10^9$ N•m^2/C^2
$\mu_o = 4\pi \times 10^{-7}$ T•m/A
$\Phi = BA\cos(\theta)$
$V = -\Delta\Phi / \Delta t = Blv$

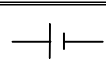
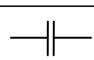
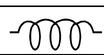
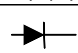
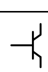
Electric circuits

$\Delta V = IR$
$I = \Delta q/\Delta t = \Delta V/R$
$\tau = RC$

$P = \Delta E / \Delta t = I\Delta V = I^2R = V^2/R$
$R = \rho l/A$
$V = -L(\Delta I/\Delta t)$

$Q = C\,\Delta V$
$C_{parallel\ plate} = \kappa\varepsilon A/d$
$C_{parallel} = C_1 + C_2 + \ldots$

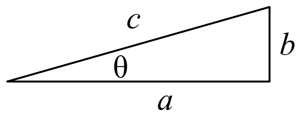
$R_{series} = R_1 + R_2 + \ldots$
$1 / R_{parallel} = (1/R_1) + (1/R_2) + \ldots$
$1 / C_{series} = (1/C_1) + (1/C_2) + \ldots$

Name	*Symbols*		*Unit*	*Typical examples*
Voltage Source	**ΔV**		Volt (V)	9 V (cell phone charger); 12 V (car); 120 VAC (U.S. wall outlet)
Resistor	**R**		Ohm (Ω)	144 Ω (100 W, 120v bulb); 1 kΩ (wet skin)
Capacitor	**C**		Farad (F)	RAM in a computer, 700 MF (Earth)
Inductor	**L**		Henry (H)	7 H (guitar pickup)
Diode	by type		none	light-emitting diode (LED); solar panel
Transistor	by type		none	Computer processors

Vector quantities are shown in **bold**; some equations provide only scalar magnitudes.
The symbol '≈' means 'approximately equal to'.

Mathematics

$\sin(\theta) = b/c \rightarrow b = c \cdot \sin(\theta)$
$\cos(\theta) = a/c \rightarrow a = c \cdot \cos(\theta)$
$\tan(\theta) = b/a \rightarrow b = a \cdot \tan(\theta)$
$c^2 = a^2 + b^2$



$180° = \pi$ radians
$C_{circle} = 2\pi R$
$A_{circle} = \pi R^2$

$V_{sphere} = (^4/_3)\pi R^3$

$V_{cylinder} = \pi R^2 h$

If X is any unit, then…

$1\ mX = 0.001\ X = 10^{-3}\ X$
$1\ \mu X = 0.000\ 001\ X = 10^{-6}\ X$
$1\ nX = 0.000\ 000\ 001\ X = 10^{-9}\ X$
$1\ kX = 1\ 000\ X = 10^3\ X$
$1\ MX = 1\ 000\ 000\ X = 10^6\ X$
$1\ GX = 1\ 000\ 000\ 000\ X = 10^9\ X$

If $ax^2 + bx + c = 0$, then…

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

% difference = |(measured – accepted) / accepted| × 100%
vector dot product: $\mathbf{a} \cdot \mathbf{b} = ab\cos\theta$ *(product is a scalar)---θ is angle between vectors*
vector cross product: $\mathbf{a} \times \mathbf{b} = ab\sin\theta$ *(direction is given by RHR)*

Kinematics under constant acceleration

$\Delta x = x_{final} - x_{initial}$
$\Delta(\text{anything}) = \text{final value} - \text{initial value}$

$\mathbf{v}_{avg} = \Delta\mathbf{x} / \Delta t$
$\mathbf{a}_{avg} = \Delta\mathbf{v} / \Delta t$

$x(t) = x_0 + v_0 t + ½a_x t^2$
$v(t) = v_0 + at$
$v^2 = v_0^2 + 2a(\Delta x)$

($x = x_0$ and $v = v_0$ at $t = 0$)

$g = 9.81\ m/s^2 \approx 10\ m/s^2$
1 km = 1000 m

1 meter = 3.28 ft
1 mile = 1.61 km

Newtonian physics and centripetal motion

$\mathbf{a} = \mathbf{F}_{net} / m$
$\mathbf{F}_g = m\mathbf{g}$
$\mathbf{F}_{net} = \sum \mathbf{F}_{all\ individual\ forces} = m\mathbf{a}$

$f_k = \mu_k F_N$
$f_s \leq \mu_s F_N$
$F_C = mv^2 / r$

$\mathbf{F}_{sp} = -k(\Delta\mathbf{x})$
$F_G = Gm_1m_2 / r^2$

$G = 6.672\times10^{-11}\ N\cdot m^2/kg^2$
1 kg = 1000 g = 2.2 lbs
$1\ N = 1\ kg\cdot m/s^2$

Momentum and energy conservation

$\sum\mathbf{p}_{initial} = \sum\mathbf{p}_{final}$

$E_{initial} = E_{final}$
$E = K + U + W$

$\mathbf{p} = m\mathbf{v}$

$K = ½\ mv^2$

$\mathbf{F}_{avg} = \Delta\mathbf{p} / \Delta t$

$U_g = mgh$
$U_{sp} = ½k(\Delta x)^2$
$U_g = -Gm_1m_2 / r$

$W = \mathbf{F}\cdot\Delta\mathbf{x}$
$P = \Delta W / \Delta t$
$P = \mathbf{F} \cdot \mathbf{v}$

$1\ J = 1\ N\cdot m$
$1\ W = 1\ J/s$
1 food Calorie = 4180 J
$1\ ev = 1.602\ X\ 10^{-19}\ J$
$1\ kwh = 3.600\ X\ 10^6\ J$

Rotational motion

$d = r\theta$
$v = r\omega$
$a = r\alpha$
$\omega = 2\pi / T$

$\theta(t) = \theta_0 + \omega_0 t + ½\alpha t^2$
$\omega(t) = \omega_0 + \alpha t$
$\omega^2 = \omega_0^2 + 2\alpha(\Delta\theta)$
$a_C = -r\omega^2$

$\boldsymbol{\tau} = I\boldsymbol{\alpha}$
$\mathbf{L} = \mathbf{r}\times\mathbf{p} = I\omega$
$\boldsymbol{\tau} = \mathbf{r}\times\mathbf{F} = \Delta\mathbf{L} / \Delta t$

$K = ½\ I\omega^2$

$I_{ring\ about\ cm} = MR^2$
$I_{disk\ about\ cm} = ½MR^2$

$I_{rod\ about\ end} = (^1/_3)ML^2$
$I_{solid\ sphere\ about\ cm} = (^2/_5)MR^2$

Astronomy

$P_☼ = 4\times10^{26}\ W$
$M_☼ = 1.99\times10^{30}\ kg$
$R_☼ = 6.96\times10^8\ m$

1 light-year (ly) $= 9.45\times10^{15}\ m$
$M_{Earth} = 5.97\times10^{24}\ kg$
$R_{Earth} = 6.38\times10^6\ m$

Earth-Sun distance $= 1.496\times10^{11}\ m$
$M_{Moon} = 7.35\times10^{22}\ kg$
$R_{Moon} = 1.74\times10^6\ m$
Earth-Moon distance $= 3.84\times10^8\ m$

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