Kinematics *One Dimension*

$v_{avg} = d/\Delta t$

$v_{x\,avg} = \Delta x/\Delta t = (x_f - x_i)/\Delta t$

$v_x = dx/dt$

$a_{x\,avg} = \Delta v_x/\Delta t = (v_{xf} - v_{xi})/\Delta t$

$v_{avg} = ½\,(v_i + v_f)$

$v_{xf} = v_{xi} + a_x\,t$

$x_f = x_i + v_i\,t + ½\,a_x\,t^2$

$v_{xf}^2 = v_{xi}^2 + 2\,a_x\,(x_f - x_i)$

$x_f = x_i + ½\,(v_f + v_i)\,t$

Projectile Motion

$v_{xi} = v_{xf}$

$x_f = x_i + v_{xi}t$

$v_{yf} = v_{yi} + a_y t$

$y_f = y_i + v_{yi}t + ½\,a_y t^2$

$v_{yf}^2 = v_{yi}^2 + 2a_y\,(y_f - y_i)$

$y_f = y_i + ½\,(v_{yf} + v_{yi})\,t$

Vectors

*If θ is the angle the vector, **V**, makes with the x axis then the components of **V** are*:

$V_x = V\cos(\theta)$

$V_y = V\sin(\theta)$

$V = (V_x^2 + V_y^2)^{1/2}$

$\tan(\theta) = V_y/V_x$

Quadratic Formula

$$at^2 + bt + c = 0$$

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

Newton's Laws and Forces

(Note Bold Symbols Represent Vector Quantities)

$\sum \mathbf{F} = m\,\mathbf{a}$

$\mathbf{F}_{AB} = -\,\mathbf{F}_{BA}$

$F_g = m\,g$

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

$F_f \le \mu_s\,F_N$

$F_f = \mu_k\,F_N$

Uniform Circular Motion

$v = 2\,\pi\,r\,/\,T$

$a_c = v^2\,/\,r$

$T = 1/f$

$a_t = d|\mathbf{v}|/dt$

Circular Motion and Gravitation

$$F_c = m\frac{v^2}{r}$$

$$v^2 = \frac{GM}{r}$$

$$g = G\frac{M}{r^2}$$

$$r^3 = \frac{GM}{4\pi^2}T^2$$

Work and Energy

$$W = \int F dr\cos\theta = \int \vec{F} \bullet d\vec{r} = F\Delta r\cos\theta = \vec{F} \bullet \Delta\vec{r}$$

$$\vec{A} \bullet \vec{B} = A_x B_x + A_y B_y + A_z B_z = AB\cos\theta$$

KE = ½mv^2

$W_{net} = \Delta K = K_f - K_i$

$U_g = mgy$ (gravitational potential energy)

$U_s = 1/2kx^2$

$E = K + U_s + U_g$ (total mechanical energy)

$W_{other} = K_f + U_{gf} + U_{sf} - K_i - U_{gi} - U_{si} = E_f - E_i$

$K_f + U_{gf} + U_{sf} = K_i + U_{gi} + U_{si}$

Momentum

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

$$\Delta\vec{p} = \int \vec{F}_{\substack{net \\ external}}\, dt = \vec{F}_{average}\Delta t$$

$$\vec{p}_{initial} = \vec{p}_{final}$$

$$\vec{p}_{1i} + \vec{p}_{2i} = \vec{p}_{1f} + \vec{p}_{2f}$$

Two body collision in one dimension (could be generalized for multi body)

$$m_1 v_{1i} + m_2 v_{2i} = m_1 v_{1f} + m_2 v_{2f}$$

$$\frac{1}{2}m_1 v_{1i}^2 + \frac{1}{2}m_2 v_{2i}^2 = \frac{1}{2}m_1 v_{1f}^2 + \frac{1}{2}m_2 v_{1f}^2$$

$$v_{1i} - v_{2i} = -(v_{1f} - v_{2f})$$

$$\vec{r}_{CM} = \frac{\sum_i m_i \vec{r}_i}{M}$$

Angular Motion

$$\omega = \frac{d\theta}{dt}$$

$$\alpha = \frac{d\omega}{dt}$$

$$\omega_f = \omega_i + \alpha t$$

$$\theta_f = \theta_i + \omega_i t + \frac{1}{2}\alpha t^2$$

$$\omega_f^2 = \omega_i^2 + 2\alpha(\theta_f - \theta_i)$$

$$\theta_f = \theta_i + \frac{1}{2}(\omega_f + \omega_i)t$$

$$s = r\theta$$

$$v_t = r\omega$$

$$a_t = r\alpha$$

$$I = \sum_i m_i r_i^2$$

$$K_R = \frac{1}{2}I\omega^2$$

$$|\vec{\tau}| = |\vec{r} \times \vec{F}| = rF\sin\theta$$

$$\sum \tau = I\alpha$$

$$|\vec{L}| = |\vec{r} \times \vec{p}| = mvr\sin\theta$$

$$\sum \vec{\tau}_{ext} = \frac{d\vec{L}_{total}}{dt}$$

$$\vec{L}_{totali} = \vec{L}_{totalf}$$

Oscillatory Motion

F_s=-kx

U_s =½ k x^2

$$\frac{d^2x}{dt^2} = -\frac{k}{m}x^2 = -\omega^2 x^2$$

$$x(t) = A\cos(\omega t + \phi)$$

T=1/f   ω = 2πf=2π/T

ω^2=k/m

E=U_{smax}=U_s+K

Wave Motion

$$y(x,t) = f(x \mp t)$$

y = A sin (kx- ωt+φ)

k=2 π/λ

v= ω/k = f λ

v^2 = F_T/μ

y = 2 A sin(kx) cos(ωt) standing waves

Electrostatics

e = 1.6 x 10^{-19} C

k_E = 8.99 x 10^9 N m^2/C^2

ε_0 = 8.85 x 10^{-12} $C^2/(Nm^2)$

$$F_E = k_E \frac{|q_1||q_2|}{r^2}$$

$$\vec{E} = \frac{\vec{F}_E}{q}$$

$$\vec{F} = q\vec{E}$$

$$\vec{E} = k_E \frac{q}{r^2}\hat{r}$$

$$\vec{E} = \sum k_E \frac{q_i}{r_i^2}\hat{r}$$

$$\vec{E} = \int k_E \frac{dq}{r^2}\hat{r}$$

$$\Phi_E = EA\cos\theta$$

$$\Phi_E = \int_{surface} \vec{E}\cdot d\vec{A}$$

$$\oint \vec{E}\cdot d\vec{A} = q_{in}/\varepsilon_0$$

$$\Delta V = \Delta U / q = -\int_A^B \vec{E}\cdot d\vec{s}$$

$$\Delta V = -\vec{E}\cdot\Delta\vec{r}$$

$$W_E = -\Delta U = -q\Delta V$$

$$V = k\frac{q}{r}$$

$$U = k\frac{q_1 q_2}{r}$$

$$E_x = -\frac{\partial V}{\partial x}$$

$$E = \frac{\sigma}{2\varepsilon_0}$$

$$E = \frac{\lambda}{2\pi\varepsilon_0 r}$$

$$dq = \lambda dl = \sigma da = \rho dV$$

Capacitance

$$C \equiv \frac{Q}{\Delta V} = \frac{Q}{V}$$

$$C_{eq} = C_1 + C_2 + C_3 + \ldots$$

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots$$

$$U = \frac{1}{2}Q\Delta V$$

$$C = \kappa C_0$$

$$C = \kappa\frac{\varepsilon_0 A}{d}$$

$$C = 4\pi\varepsilon_0 \frac{ab}{b-a}$$

Circuits

$$I = \frac{dQ}{dt}$$

$$R \equiv \frac{\Delta V}{I} = \frac{V}{I} = \frac{\rho l}{A}$$

$$\rho = \rho_0[1 + \alpha(T - T_0)]$$

$$P = I\Delta V = IV$$

$$R_{eq} = R_1 + R_2 + R_3 + \ldots$$

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$$

$$q = q_0 e^{-\frac{t}{RC}}$$

$$\tau = RC$$

Magnetism

$\mu_0 = 4\pi \times 10^{-7}$ Tm/A

$$\vec{F}_B = q\vec{v} \times \vec{B} = Id\vec{l} \times \vec{B}$$

$$F_B = |q| vB\sin\theta$$

$$r = \frac{mv}{qB}$$

$$\vec{\mu} = I\vec{A}$$

$$\vec{\tau} = \vec{\mu} \times \vec{B}$$

$$B = \frac{\mu_0 I}{2\pi r}$$

$$\frac{F}{l} = \frac{\mu_0 I_1 I_2}{2\pi r}$$

$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{Id\vec{s} \times \hat{r}}{r^2}$$

$$\oint \vec{B} \cdot d\vec{s} = \mu_0 I$$

Faraday's Law

$$\Phi_B = \int \vec{B} \cdot d\vec{A} = BA\cos\theta$$

$$V = -N\frac{d\Phi_B}{dt}$$

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