Physics 121 Common Exam 2 Formulas

Area of circle = πr^2 Circumference of circle = $2\pi r$ 1 meter = 1000 mm = 100 cm 1 kg = 1000 g

Surface area of sphere = $4\pi r^2$ Volume of a sphere = $(4/3)\pi r^3$, $1\ \mu C = 10^{-6}$ C 1 nC = 10^{-9} C

$1/4\pi\varepsilon_o = k_e = 9 \times 10^9\ N\text{-}m^2/C^2$ $\varepsilon_o = 8.85 \times 10^{-12}\ C^2/N\text{-}m^2$, $e = 1.60 \times 10^{-19}$ C , $m_e = 9.11 \times 10^{-31}$ kg

Point charges: $\vec{F} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}\hat{r}$ $\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}\hat{r}$ where $\hat{r}$ is a unit vector $k_e \equiv \frac{1}{4\pi\varepsilon_0} = 9x10^9$

Superposition: contributions to the field or force from point charges add as vectors at a point of interest $\vec{F}_{net\ on\ 1} = \sum_{i=2}^{n}\vec{F}_{1,i} = \vec{F}_{1,2} + \vec{F}_{1,3} + \vec{F}_{1,4+.....}$

Shell Theorem (spheres only): mimics a point charge from outside; inside **E** or **F** is zero

E = force per unit test charge at a point **F** = q**E** $\mathbf{F}_{net} = m\mathbf{a}$

Dipole moment: **p** = q**d** $\tau_{dipole} = \mathbf{p} X \mathbf{E}$ $U_{dipole} = -\mathbf{p}.\mathbf{E}$ $E_{on\ dipole\ axis} \approx +p/2\pi\varepsilon_0 z^3$ for large z

For continuous charge distributions: $\vec{E} = \int_{dist} k_e \frac{dq}{r^2}\hat{r}$ and $V = \int_{dist} k_e \frac{dq}{r}$. (integrate over the distribution)

σ = surface charge density $E_{conducting\ sheet} = \sigma/\varepsilon_o$ $E_{non\text{-}conducting\ sheet} = \sigma/2\varepsilon_o$

λ = linear charge density $E_{infinite\ line} = \lambda/2\pi\varepsilon_o r$ $E_{finite\ line} = \lambda\sin(\theta_0)/2\pi\varepsilon_o d$ $E_{arc} = \lambda\sin(\theta_0)/2\pi\varepsilon_o R$

$d\Phi_E = \mathbf{E}\ .\ \mathbf{n}dA = EA\cos(\phi)$ Φ_E = electric flux = $q_{enc}/\varepsilon_o = \oint \mathbf{E}\ .\ \mathbf{dA}$ over a Gaussian surface

$\Delta V = \Delta U/q = -\oint E\cos\theta\, ds = -\oint \mathbf{E}\ .\ \mathbf{ds}$ $\Delta U_{el} = q\Delta V$ $V = k_e Q/r$ $U = k_e Qq/r$ $V_f - V_o = -E(x_f - x_o)$

$E_x = -\partial V/\partial x$ $E_y = -\partial V/\partial y$ $E_z = -\partial V/\partial z$ Q = CV PE: $U_{el} = Q^2/2C = CV^2/2$

$\Delta W_{nc} = \Delta E_{mech} = \Delta K + \Delta U$ $C_{parallel} = \Sigma C_i$ $1/C_{series} = \Sigma\,(1/C_i)$ $C_{series} = C_1C_2/(C_1+C_2)$

$C_{parallel\ plates} = \kappa\varepsilon_o A/d$ $C_{sphere} = 4\pi\varepsilon_o R$ Dielectric constant: $C_{diel} = \kappa\, C_{vac}$ $\kappa >= 1$

$q = \oint i dt = i\Delta t$ dq = idt i = dq/dt $i = \oint \mathbf{J}\bullet \mathbf{d^2A} = J\Delta A$ $J = qnv_{drift}$ $J = \sigma E$ $\sigma = 1/\rho$

R = V / i V = iR R = ρL/A $\rho = \rho_0(1 + \alpha(T - T_0))$ **Ohms Law: R independent of V**

$R_{series} = \Sigma R_i$ $1/R_{parallel} = \Sigma 1/R_i$ $R_{para} = R_1R_2/(R_1 + R_2)$ $P = dU_{el}/dt = iV$ $P_{resistor} = i^2R = V^2/R$

Junction rule: $\Sigma i_{in} = \Sigma i_{out}$ Loop rule: $\Sigma\,\Delta V_i = 0$ around any closed circuit path. $\Delta V = -iR$ when following assumed currents, +iR otherwise. EMF's positive when crossing from – to +, negative otherwise.

Prefixes: n (nano) = 10^{-9} , μ (micro) = 10^{-6} , m (milli) = 10^{-3}, p (pico) = 10^{-12}

Useful Integrals: $\int x^n dx = x^{n+1}/(n+1)$ $\int dx/(x+a) = \ln(x+a)$ $\int e^{\pm\alpha x}dx = \pm e^{\alpha x}/\alpha$

$\int x\,dx/(a^2+x^2)^{3/2} = -1/\sqrt{a^2+x^2}$ $\int dx/(a-x)^2 = 1/(a-x)$ $\int dx/(a^2+x^2) = (1/a)\tan^{-1}(x/a)$

$\int dx/(x^2+a^2)^{1/2} = \ln(x+(x^2+a^2)^{1/2})$ $\int dx/(a^2+x^2)^{3/2} = x/(a^2\sqrt{a^2+x^2})$ $\int x dx/(x^2+a^2)^{1/2} = (x^2+a^2)^{1/2}$

Physics 1: $v = v_o + at$ $x - x_o = v_o t + ½at^2$ $v^2 = v_o^2 + 2a(x - x_o)$ $x - x_o = ½(v + v_o)t$

$a_c = v^2/r$ $\underline{\mathbf{F}}_{net} = m\underline{\mathbf{a}} = d\underline{\mathbf{p}}/dt$ $\tau_{net} = I\alpha = d\underline{\mathbf{L}}/dt$ $\underline{\tau} = \underline{\mathbf{r}} \times \underline{\mathbf{F}}$ $\underline{\mathbf{L}} = \underline{\mathbf{r}} \times \underline{\mathbf{p}}$

Vector Addition: **a** + **b** = **c** implies $c_x = a_x + b_x$, $c_y = a_y + b_y$

2D: $a = a_x\mathbf{i} + a_y\mathbf{j}$ $a_x = a\cdot\cos(\theta)$ $a_y = a\cdot\sin(\theta)$ $|a| = \text{sqrt}[a_x^2 + a_y^2]$ $\theta = \tan^{-1}(a_y/a_x)$

3D: $a = a_x\mathbf{i} + a_y\mathbf{j} + a_z\mathbf{k}$ $a_z = a.\cos(\theta)$ $a_x = a.\sin(\theta)\cos(\phi)$ $a_y = a\cdot\sin(\theta)\sin(\phi)$

Dot product: $\mathbf{a}\cdot\mathbf{b} = a\cdot b\cdot\cos(\phi) = a_xb_x + a_yb_y + a_zb_z$ unit vectors: $\mathbf{i}\cdot\mathbf{i} = \mathbf{j}\cdot\mathbf{j} = \mathbf{k}\cdot\mathbf{k} = 1$; $\mathbf{i}\cdot\mathbf{j} = \mathbf{i}\cdot\mathbf{k} = \mathbf{j}\cdot\mathbf{k} = 0$

Cross product: $|\mathbf{a \times b}| = a\cdot b\cdot\sin(\phi)$; $\mathbf{c} = \mathbf{a \times b} = (a_y\cdot b_z - a_z\cdot b_y)\cdot\mathbf{i} + (a_z\cdot b_x - a_x\cdot b_z)\cdot\mathbf{j} + (a_x\cdot b_y - a_y\cdot b_x)\cdot\mathbf{k}$

a x b = – b x a, a x a = 0 always; **c = a x b** is perpendicular to **a-b** plane; if **a** || **b** then | **a x b** | = 0

i x i = j x j = k x k = 0, **i x j = k j x k = i k x i = j**