PS 250 Exam 1 formulas

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April 27, 2025

1 Units

$$\text{exponents (negative): } c, m, \mu, n, p = 2, 3, 6, 9, 12 \tag{1}$$

$$\mathrm{F} = \frac{\mathrm{C}}{\mathrm{V}} = \frac{\mathrm{C}^2\ \mathrm{s}^2}{\mathrm{kg\ m}^2} \tag{2}$$

$$\mathrm{V} = \frac{\mathrm{J}}{\mathrm{C}} = \frac{\mathrm{kg\ m}^2}{\mathrm{C\ s}^2} \tag{3}$$

$$\mathrm{N} = \frac{\mathrm{kg\ m}}{\mathrm{s}^2} \tag{4}$$

$$\mathrm{J} = \mathrm{N\ m} = \frac{\mathrm{kg\ m}^2}{\mathrm{s}^2} \tag{5}$$

$$1\,\mathrm{eV} = |e|\,\mathrm{C} \tag{6}$$

2 Constants

$$k = 8.987551787\textsc{e}{+}9 \qquad \left[\frac{\mathrm{m}}{\mathrm{F}}\right] \tag{1}$$

$$\varepsilon_0 = 8.8541878188\textsc{e}{-}12 \qquad \left[\frac{\mathrm{F}}{\mathrm{m}}\right] \tag{2}$$

$$e = 1.602176634\textsc{e}{-}19 \qquad [\mathrm{C}] \tag{3}$$

$$m_e = 9.10938356\textsc{e}{-}31 \qquad [\mathrm{kg}] \tag{4}$$

$$m_p = 1.672621898\textsc{e}{-}27 \qquad [\mathrm{kg}] \tag{5}$$

$$m_n = 1.674927471\textsc{e}{-}27 \qquad [\mathrm{kg}] \tag{6}$$

3 Formulas

$$F = k\frac{|q_1 q_2|}{r^2} \tag{1}$$

$$E = \frac{F}{q_t} = k\frac{|Q|}{r^2} = -\nabla V = -\frac{\mathrm{d}V}{\mathrm{d}x} \tag{2}$$

$$W = -\Delta U = q_t \Delta V = \int \mathbf{F} \cdot \mathrm{d}\mathbf{r} \tag{3}$$

$$W = q_t E d \quad \text{(uniform field. } d \text{ is the displacement)} \tag{4}$$

$$U = k\frac{q_1 q_2}{r} \tag{5}$$

$$U_{\text{sys}} = k\sum_{i<j} \frac{q_i q_j}{r_{i,j}} \tag{6}$$

$$\Phi_E = \oint \mathbf{E} \cdot \mathrm{d}\mathbf{A} = \frac{Q_{\text{encl}}}{\varepsilon_0} \tag{7}$$

$$V = \sum k\frac{Q_i}{r_i} = \frac{U}{q_t} = \int \frac{\mathrm{d}q}{r} \tag{8}$$

$$E_{\text{tot}} = \sum_i E_i \tag{9}$$

4 Specific Situations: Electric Field

$$\text{Line: } E = \frac{k\lambda}{d}\left[\frac{a}{\sqrt{a^2+d^2}} + \frac{b}{\sqrt{b^2+d^2}}\right] \approx \frac{2k\lambda}{d} \tag{1}$$

$$\text{Disk: } E = \frac{\sigma}{2\varepsilon_0}\left[1 - \frac{d}{\sqrt{d^2+R^2}}\right] \approx \frac{\sigma}{2\varepsilon_0} = 2\pi k\sigma \tag{2}$$

$$\text{Ring: } E = \frac{kQd}{(d^2+R^2)^{3/2}}, Q = 2\pi\lambda R \tag{3}$$

$$\text{Sphere: } E = k\frac{Q}{r^2} \text{ if outside, else } 0 \tag{4}$$

$$\text{non-conducting uniformly charged cylinder: } E = \frac{2k\lambda d}{R^2} \tag{5}$$

5 Specific Situations: Voltage

$$\text{Conducting Cylinder radius } R \text{ (line): } V = 2k\lambda \ln\frac{R}{d} \text{ if } d > R \text{ else } 0 \tag{1}$$

$$\text{Ring: } V = \frac{kQ}{\sqrt{d^2+R^2}} \tag{2}$$