

**THE CITADEL  
THE MILITARY COLLEGE OF SOUTH CAROLINA**

**Department of Electrical and Computer Engineering**

**ELEC 318 Electromagnetic Fields**

**Exam #2 Review Problem Answers**

1. 
$$\begin{cases} 0 \text{ A} & r \leq a \\ 10(r-a) \text{ A} & a \leq r \leq b \\ 10(b-a) \text{ A} & r \geq b \end{cases}$$
2. 93.75 A
3. 100 A
4.  $\frac{\pi J_0}{6}(b^4 - a^4) \text{ (A)}$
5.  $3.5 \times 10^7 \text{ S/m}$
6. 3.4  $\Omega$
7. (a) 33.95 m $\Omega$   
(b) 265.1 A  
(c) 2.386 kW
8. 0.84  $\Omega$
9. 13.26 m $\Omega$
10.  $4t / [\pi \sigma (b^2 - a^2)]$
11.  $\pi / [2 \sigma t \ln(b/a)]$
12.  $L / \left\{ \pi \left[ \sigma_1 a^2 + \sigma_2 (b^2 - a^2) \right] \right\}$
13. (a) 14 m $\Omega$   
(b) 5.71 p $\Omega$
14. (a)  $\frac{20}{\epsilon_0} \hat{\mathbf{r}} \left( \frac{\text{nV}}{\text{m}} \right)$   
(b)  $70 \hat{\mathbf{r}} \frac{\text{nC}}{\text{m}^2}$
15. 262.5  $\hat{\mathbf{x}} \text{ nC/m}^2$
16. 1.25
17. (a)  $-20xyz\hat{\mathbf{x}} - 10x^2z\hat{\mathbf{y}} - 10(x^2y - z)\hat{\mathbf{z}} \text{ V/m}$   
(b)  $-0.884xyz\hat{\mathbf{x}} - 0.442x^2z\hat{\mathbf{y}} - 0.442(x^2y - z)\hat{\mathbf{z}} \text{ nC/m}^2$
- (c)  $-0.707xyz\hat{\mathbf{x}} - 0.354x^2z\hat{\mathbf{y}} - 0.354(x^2y - z)\hat{\mathbf{z}} \text{ nC/m}^2$
- (d)  $-0.8854yz + 0.4427 \text{ nC/m}^3$
18. (a)  $90\hat{\mathbf{x}} - 4\hat{\mathbf{y}} \text{ V/cm}$   
(b)  $31.1^\circ$
19. (a)  $12.96\hat{\mathbf{x}} - 6\hat{\mathbf{y}} + 25.92\hat{\mathbf{z}} \text{ nC/m}^2$   
(b)  $181\hat{\mathbf{x}} - 83.8\hat{\mathbf{y}} + 362\hat{\mathbf{z}} \text{ V/m}$
20. (a)  $0.177\hat{\mathbf{x}} - 0.106\hat{\mathbf{y}} + 0.212\hat{\mathbf{z}} \text{ nC/m}^2$   
(b)  $10\hat{\mathbf{x}} - 4\hat{\mathbf{y}} + 12\hat{\mathbf{z}} \text{ V/m}$   
(c)  $\pm 75.64^\circ$
21. 150.3 pC/m $^2$
22.  $20\hat{\mathbf{y}} \text{ nC/m}^2$
23.  $1\hat{\mathbf{x}} - 2\hat{\mathbf{y}} + 1000\hat{\mathbf{z}} \text{ V/m}$
24. (a)  $r^2/2\hat{\mathbf{r}} - r\cos\phi\hat{\phi} + 3\hat{\mathbf{z}} \text{ (V/m)}$   
(b)  $8\epsilon_0(r^2/2\hat{\mathbf{r}} - r\cos\phi\hat{\phi} + 3\hat{\mathbf{z}}) \text{ (C/m}^2\text{)}$
25.  $6\cos\theta\hat{\mathbf{R}} - 3\sin\theta\hat{\theta} \text{ (V/m)}$
26.  $\theta_1 = 71.6^\circ, \theta_2 = 78.7^\circ, \theta_3 = 81.9^\circ$
28. (a)  $0.866\hat{\mathbf{r}} - 1.5\hat{\phi} \text{ V/m}$   
(b)  $13.78\hat{\mathbf{r}} - 23.87\hat{\phi} \text{ pC/m}^2$   
(c)  $171.52 \text{ pC/m}^3$
29.  $157y^4 - 943y^2 + 30.4 \text{ kV}$
30. (a) 25z kV  
(b)  $-25\hat{\mathbf{z}} \text{ kV/m}$   
(c)  $-332\hat{\mathbf{z}} \text{ nC/m}^2$   
(d)  $\pm 332 \text{ nC/m}^2$
31.  $-2.2 \text{ V}, +3.3 \text{ V}$

$$32. (a) -\frac{100}{R} + 150 \text{ V}$$

$$(b) -\frac{100}{R^2} \hat{\mathbf{R}} \frac{\text{V}}{\text{m}}$$

$$33. \begin{cases} a^3 \rho_0 / 3 \epsilon_0 R & R \geq a \\ \frac{\rho_0}{6 \epsilon_0} (a^2 - R^2) + \frac{\rho_0 a^2}{3 \epsilon_0} & R < a \end{cases}$$

$$34. (a) V_0 \left( 1 + \frac{\rho_0 d}{2 \epsilon_0 V_0} z \right) \left( 1 - \frac{z}{d} \right)$$

$$(b) \frac{V_0}{d} \left\{ 1 - \frac{\rho_0 d^2}{2 \epsilon_0 V_0} \left( 1 - 2 \frac{z}{d} \right) \right\} \hat{\mathbf{z}}$$

$$35. -8.05 \mu\text{J}$$

$$36. 4.62 \text{ nJ}$$

$$37. 1.89 \text{ nJ}$$

$$38. 6.67 \text{ nJ}$$

$$39. (a) -\hat{\mathbf{r}} V_0 / [r \ln(b/a)]$$

$$(b) \epsilon \phi_0 h / \ln(b/a)$$

$$40. (a) 59 \text{ pF}$$

$$(b) 339.3 \text{ V}$$

$$(c) 2.26 \text{ mN}$$

$$41. (a) 30 \text{ nC}$$

$$(b) 5 \text{ nF}$$

$$42. 3.173 \text{ nF}$$

$$43. 4\pi \left/ \frac{\epsilon_1}{\frac{1}{d} - \frac{1}{c}} + \frac{\epsilon_2}{\frac{1}{c} - \frac{1}{b}} + \frac{\epsilon_3}{\frac{1}{b} - \frac{1}{a}} \right.$$

$$44. 5 \text{ pF}$$

$$45. \epsilon_1 A_1 / d + \epsilon_2 A_2 / d$$

$$46. \frac{\epsilon_1 \epsilon_2 A}{\epsilon_2 d_1 + \epsilon_1 d_2}$$

$$47. 6.07 \text{ pF}$$

$$48. \frac{Q}{4\pi\epsilon_0} \left[ \frac{1}{r_1} - \frac{1}{r_2} + \frac{1}{r_3} - \frac{1}{r_4} \right], \text{ where}$$

$$r_1 = \sqrt{(x-a)^2 + (y-a)^2 + z^2} \quad r_2 = \sqrt{(x+a)^2 + (y-a)^2 + z^2}$$

$$r_3 = \sqrt{(x+a)^2 + (y+a)^2 + z^2} \quad r_4 = \sqrt{(x-a)^2 + (y+a)^2 + z^2}$$

$$49. -0.109 (\hat{\mathbf{x}} + \hat{\mathbf{y}} + \hat{\mathbf{z}}) \text{ N}$$

$$50. (a) 32 \hat{\mathbf{y}} - 24 \hat{\mathbf{z}} \text{ V/m}$$

$$(b) 0$$

$$51. (a) \text{ upward}$$

$$(b) \text{ to the left}$$