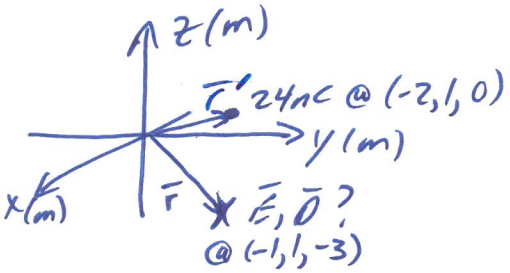
EE 381 Electric and Magnetic Fields Quiz #8 (Fall 2024)

Name Key A

Instructions: Open book & notes. Place answers in indicated spaces and **show all** work for credit.

A 24 nC point charge is located at (-2, 1, 0) in free space. Find the electric field and electric flux density vectors at (-1, 1, -3). All locations are in units of meters.



Use $\bar{E} = \frac{Q(\bar{r}-\bar{r}')}{4\pi\epsilon_0|\bar{r}-\bar{r}'|^3}$ (4.11a)

source $\bar{r}' = -2\hat{a}_x + \hat{a}_y$ (m)

Field $\bar{r} = -\hat{a}_x + \hat{a}_y - 3\hat{a}_z$ (m)

$\bar{r} - \bar{r}' = (-1+2)\hat{a}_x + (1-1)\hat{a}_y + (-3-0)\hat{a}_z$

$= \hat{a}_x - 3\hat{a}_z$ (m)

$|\bar{r}-\bar{r}'| = \sqrt{1^2+(-3)^2} = \sqrt{10}$ (m)

$$\bar{E} = \frac{24\times10^{-9}(\hat{a}_x - 3\hat{a}_z)}{4\pi\, 8.8541878\times10^{-12}\,(10)^{3/2}} = 6.82107(\hat{a}_x - 3\hat{a}_z)\ V/m$$

$$= 6.8211\hat{a}_x - 20.46322\hat{a}_z\ V/m$$

$\bar{D} = \epsilon_0\bar{E}$ per (4.35)

$= 8.8541878\times10^{-12}(6.8211\hat{a}_x - 20.46322\hat{a}_z)$

$= 6.0395055\times10^{-11}\hat{a}_x - 1.8118516\times10^{-10}\hat{a}_z\ C/m^2$

electric field vector = $\bar{E} = 6.8211\hat{a}_x - 20.4632\hat{a}_z$ (V/m)

$\bar{D}$ = electric flux density vector = $60.395\hat{a}_x - 181.185\hat{a}_z$ (pC/m²)

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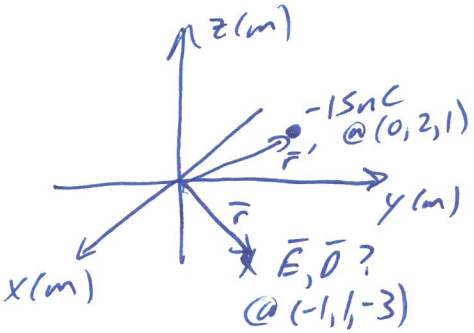
Name Key B

Instructions: Open book & notes. Place answers in indicated spaces and **show all** work for credit.

A -15 nC point charge is located at (0, 2, 1) in free space. Find the electric field and electric flux density vectors at (-1, 1, -3). All locations are in units of meters.



Use $\bar{E} = \frac{Q(\bar{r}-\bar{r}')}{4\pi\epsilon_0|\bar{r}-\bar{r}'|^3}$ (4.11a)

Source $\bar{r}' = 2\hat{a}_y + \hat{a}_z$ (m)

field $\bar{r} = -\hat{a}_x + \hat{a}_y - 3\hat{a}_z$ (m)

$\bar{r}-\bar{r}' = (-1-0)\hat{a}_x + (1-2)\hat{a}_y + (-3-1)\hat{a}_z$

$= -\hat{a}_x - \hat{a}_y - 4\hat{a}_z$ (m)

$|\bar{r}-\bar{r}'| = \sqrt{(-1)^2+(-1)^2+(-4)^2} = \sqrt{18}$ (m)

$\bar{E} = \frac{-15\times10^{-9}(-\hat{a}_x-\hat{a}_y-4\hat{a}_z)}{4\pi\, 8.8541878\times10^{-12}(18)^{3/2}} = 1.76532(\hat{a}_x+\hat{a}_y+4\hat{a}_z)$

$= 1.76532\hat{a}_x + 1.76532\hat{a}_y + 7.06129\hat{a}_z$ (V/m)

(4.35) $\bar{D} = \epsilon_0\bar{E} = 8.8541878\times10^{-12}(1.76532\hat{a}_x + 1.76532\hat{a}_y + 7.06129\hat{a}_z)$

$= 1.56305\times10^{-11}\hat{a}_x + 1.56305\times10^{-11}\hat{a}_y + 6.2522\times10^{-11}\hat{a}_z$ C/m²

$\bar{E}$ = electric field vector = $1.7653\hat{a}_x + 1.7653\hat{a}_y + 7.0613\hat{a}_z$ (V/m)

$\bar{D}$ = electric flux density vector = $15.6305\hat{a}_x + 15.6305\hat{a}_y + 62.522\hat{a}_z$ (pC/m²)

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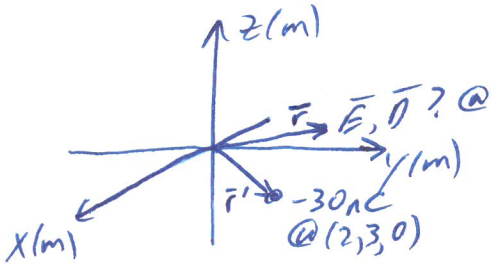
Name Key C

Instructions: Open book & notes. Place answers in indicated spaces and **show all** work for credit.

A -30 nC point charge is located at (2, 3, 0) in free space. Find the electric field and electric flux density vectors at (-3, 1, -1). All locations are in units of meters.



use $\bar{E} = \frac{Q(\bar{r}-\bar{r}')}{4\pi\epsilon_0|\bar{r}-\bar{r}'|^3}$ (4.11a)

source $\bar{r}' = 2\hat{a}_x + 3\hat{a}_y$ (m)

field $\bar{r} = -3\hat{a}_x + \hat{a}_y - \hat{a}_z$ (m)

$$\bar{r}-\bar{r}' = (-3-2)\hat{a}_x + (1-3)\hat{a}_y + (-1-0)\hat{a}_z$$
$$= -5\hat{a}_x - 2\hat{a}_y - \hat{a}_z \text{ (m)}$$

$$|\bar{r}-\bar{r}'| = \sqrt{(-5)^2+(-2)^2+(-1)^2} = \sqrt{30} \text{ (m)}$$

$$\bar{E} = \frac{-30\times10^{-9}(-5\hat{a}_x - 2\hat{a}_y - \hat{a}_z)}{4\pi\, 8.854187\times10^{-12}\,(30)^{3/2}} = 1.640895(5\hat{a}_x + 2\hat{a}_y + \hat{a}_z)$$
$$= 8.204475\hat{a}_x + 3.281789\hat{a}_y + 1.640895\hat{a}_z \text{ (V/m)}$$

(4.35) $\bar{D} = \epsilon_0\bar{E} = 8.854187\times10^{-12}(8.2045\hat{a}_x + 3.2818\hat{a}_y + 1.6409\hat{a}_z)$

$$\bar{D} = 7.2644\times10^{-11}\hat{a}_x + 2.9058\times10^{-11}\hat{a}_y + 1.4529\times10^{-11}\hat{a}_z \text{ (C/m}^2\text{)}$$

$\bar{E}$ = electric field vector = $8.2045\hat{a}_x + 3.2818\hat{a}_y + 1.6409\hat{a}_z$ (V/m)

$\bar{D}$ = electric flux density vector = $72.644\hat{a}_x + 29.058\hat{a}_y + 14.529\hat{a}_z$ (pC/m^2)

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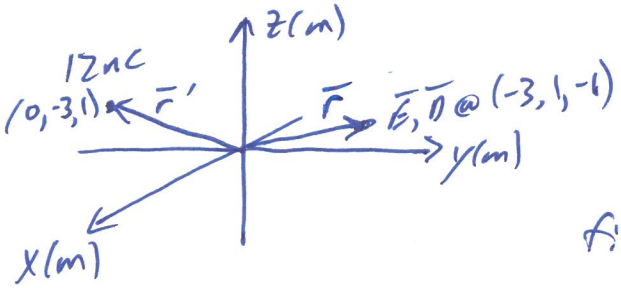
Name Key D

Instructions: Open book & notes. Place answers in indicated spaces and **show all** work for credit.

A 12 nC point charge is located at (0, -3, 1) in free space. Find the electric field and electric flux density vectors at (-3, 1, -1). All locations are in units of meters.



use $\bar{E} = \dfrac{Q(\bar{r}-\bar{r}')}{4\pi\epsilon_0 |\bar{r}-\bar{r}'|^3}$ (4.11a)

source $\bar{r}' = -3\hat{a}_y + \hat{a}_z$ (m)

field $\bar{r} = -3\hat{a}_x + \hat{a}_y - \hat{a}_z$ (m)

$$\bar{r}-\bar{r}' = (-3-0)\hat{a}_x + (1+3)\hat{a}_y + (-1-1)\hat{a}_z$$
$$= -3\hat{a}_x + 4\hat{a}_y - 2\hat{a}_z \text{ (m)}$$

$$|\bar{r}-\bar{r}'| = \sqrt{(-3)^2 + 4^2 + (-2)^2} = \sqrt{29}\text{ m}$$

$$\bar{E} = \frac{12\times10^{-9}(-3\hat{a}_x + 4\hat{a}_y - 2\hat{a}_z)}{4\pi\, 8.8541878\times10^{-12}\,(29)^{3/2}} = 0.6906(-3\hat{a}_x + 4\hat{a}_y - 2\hat{a}_z)$$

$$\bar{E} = -2.0718\,\hat{a}_x + 2.7624\,\hat{a}_y - 1.3812\,\hat{a}_z \text{ (V/m)}$$

(4.35) $\bar{D} = \epsilon_0 \bar{E} = 8.8542\times10^{-12}(-2.0718\hat{a}_x + 2.7624\hat{a}_y - 1.3812\hat{a}_z)$

$$= -1.8344\times10^{-11}\hat{a}_x + 2.4459\times10^{-11}\hat{a}_y - 1.2229\times10^{-11}\hat{a}_z \text{ (C/m}^2\text{)}$$

$\bar{E}$ = electric field vector = $-2.0718\,\hat{a}_x + 2.7624\,\hat{a}_y - 1.3812\,\hat{a}_z$ (V/m)

$\bar{D}$ = electric flux density vector = $-18.344\,\hat{a}_x + 24.459\,\hat{a}_y - 12.229\,\hat{a}_z$ (pC/m^2)