Solutions to *Introduction to Electrodynamics* 3rd ed. (D. J. Griffiths)

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These are solution to problems found in the 3rd edition of Griffiths' *Introduction to Electrodynamics* — they are inspired by problems I did not invent.

Physics students cannot learn the proper methods to problem solving unless they first make a serious attempt (i.e. at least an hour) at solving the problem on their own before seeking help.

I will continue to update this solution manual until I complete all of the problems. If you see any errors, they are entirely mine (but also let me know so I can correct them).

Problem 1.1

Problem 1.2

Problem 1.7

We find the separation vector $\mathbf{r} - \mathbf{r}'$ from a source point to a field point. A vector $\mathbf{r}'$ which points from the origin to the source point has components $\mathbf{r}' = (2, 8, 7)$. Another vector $\mathbf{r}$ which points from the origin to the field point has components $\mathbf{r} = (4, 6, 8)$.

$\mathbf{r} - \mathbf{r}' = (4-2)\hat{\mathbf{e}}_1 + (6-8)\hat{\mathbf{e}}_2 + (8-7)\hat{\mathbf{e}}_3$

$\boxed{\mathbf{r} - \mathbf{r}' = 2\hat{\mathbf{e}}_1 - 2\hat{\mathbf{e}}_2 + \hat{\mathbf{e}}_3}$

Next, we calculate the magnitude $|\mathbf{r} - \mathbf{r}'|$.

$|\mathbf{r} - \mathbf{r}'| = \sqrt{(r_1 - r_1')^2 + (r_2 - r_2') + (r_3 - r_3')}$

$|\mathbf{r} - \mathbf{r}'| = \sqrt{(4-2)^2 + (6-8)^2 + (8-7)^2}$

$\boxed{|\mathbf{r} - \mathbf{r}'| = 3}$

Finally, we construct the unit vector $\frac{\mathbf{r}-\mathbf{r}'}{|\mathbf{r}-\mathbf{r}'|}$.

$\boxed{\frac{\mathbf{r} - \mathbf{r}'}{|\mathbf{r} - \mathbf{r}'|} = \frac{2}{3}\hat{\mathbf{e}}_1 - \frac{2}{3}\hat{\mathbf{e}}_2 + \frac{1}{3}\hat{\mathbf{e}}_3}$ ■

Problem 1.11

First, we calculate the gradient of the function $f(x, y, z) = x^2 + y^3 + z^4$.

$$\boxed{\nabla f = 2x\hat{\mathbf{e}}_1 + 3y^2\hat{\mathbf{e}}_2 + 4z^3\hat{\mathbf{e}}_3}$$

Next, we calculate the gradient of the function $f(x, y, z) = x^2y^3z^4$.

$$\boxed{\nabla f = 2xy^3z^4\hat{\mathbf{e}}_1 + 3x^2y^2z^4\hat{\mathbf{e}}_2 + 4x^2y^3z^3\hat{\mathbf{e}}_3}$$

Finally, we calculate the gradient of the function $f(x, y, z) = e^x \sin y \ln z$.

$$\boxed{\nabla f = e^x \sin y \ln z\hat{\mathbf{e}}_1 + e^x \cos y \ln z\hat{\mathbf{e}}_2 + \frac{\sin y \ln z}{z}\hat{\mathbf{e}}_3} \quad \blacksquare$$

Problem 1.15

First, we calculate the divergence of the vector function $\mathbf{v}_a = x^2\hat{\mathbf{e}}_1 + 3xz^2\hat{\mathbf{e}}_2 - 2xz\hat{\mathbf{e}}_3$.

$$\boxed{\nabla \cdot \mathbf{v}_a = 2x + 0 - 2x = 0}$$

Next, we calculate the divergence of the vector function $\mathbf{v}_b = xy\hat{\mathbf{e}}_1 + 2yz\hat{\mathbf{e}}_2 + 3zx\hat{\mathbf{e}}_3$.

$$\boxed{\nabla \cdot \mathbf{v}_b = y + 2z + 3x}$$

Finally, we calculate the divergence of the vector function $\mathbf{v}_c = y^2\hat{\mathbf{e}}_1 + (2xy + z^2)\hat{\mathbf{e}}_2 + 2yz\hat{\mathbf{e}}_3$.

$$\boxed{\nabla \cdot \mathbf{v}_c = 0 + 2x + 2y} \quad \blacksquare$$

Problem 1.39

We compute the divergence of the function $\mathbf{v} = (r\cos\theta)\hat{\mathbf{r}} + (r\sin\theta)\hat{\theta} + (r\sin\theta\cos\phi)\hat{\phi}$.

$\nabla \cdot \mathbf{v} = \frac{1}{r^2}\frac{\partial}{\partial r}(r^3\cos\theta) + \frac{1}{r\sin\theta}\frac{\partial}{\partial\theta}(r\sin^2\theta) + \frac{1}{r\sin\theta}\frac{\partial}{\partial\phi}(r\sin\theta\cos\phi)$

$$\boxed{\nabla \cdot \mathbf{v} = 5\cos\theta - \sin\theta}$$

Next, we check if the function $\mathbf{v}$ satisfies the divergence theorem. As a volume we choose an inverted hemispherical bowl of radius R, which is centered and resting at the origin of the xy-plane.

References

Griffiths, D. J. *Introduction to Electrodynamics*, 3rd ed., Prentice-Hall, Inc., 1999.