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$$
\begin{aligned}
\nabla\cdot\vec{A} &= \left(\frac{\partial}{\partial s}\hat{s}+\frac{1}{s}\frac{\partial}{\partial\phi}\hat{\phi}+\frac{\partial}{\partial z}\hat{z}\right)(A_s\hat{s}+A_\phi\hat{\phi}+A_z\hat{z}) = \frac{\partial\vec{A}}{\partial s}\hat{s}+\frac{1}{s}\frac{\partial\vec{A}}{\partial\phi}\hat{\phi}+\frac{\partial\vec{A}}{\partial z}\hat{z}\\
&= \hat{s}\left(\frac{\partial A_s}{\partial s}\hat{s}+A_s\cancelto{0}{\frac{\partial\hat{s}}{\partial s}}+\frac{\partial A_\phi}{\partial s}\hat{\phi}+\cancelto{0}{\frac{\partial\hat{\phi}}{\partial s}}A_\phi+\frac{\partial A_z}{\partial s}\hat{z}+\cancelto{0}{\frac{\partial\hat{z}}{\partial s}}A_z\right)+\\
&\quad \frac{\hat{\phi}}{s}\left(\frac{\partial A_s}{\partial\phi}\hat{s}+A_s\cancelto{\hat{\phi}}{\frac{\partial\hat{s}}{\partial\phi}}+\frac{\partial A_\phi}{\partial\phi}\hat{\phi}+\cancelto{-\hat{s}}{\frac{\partial\hat{\phi}}{\partial\phi}}A_\phi+\frac{\partial A_z}{\partial\phi}\hat{z}+\cancelto{0}{\frac{\partial\hat{z}}{\partial\phi}}A_z\right)+\\
&\quad \hat{z}\left(\frac{\partial A_s}{\partial z}\hat{s}+A_s\cancelto{0}{\frac{\partial\hat{s}}{\partial z}}+\frac{\partial A_\phi}{\partial z}\hat{\phi}+\cancelto{0}{\frac{\partial\hat{\phi}}{\partial z}}A_\phi+\frac{\partial A_z}{\partial z}\hat{z}+\cancelto{0}{\frac{\partial\hat{z}}{\partial z}}A_z\right)\\
&= \frac{\partial A_s}{\partial s}+\frac{1}{s}\frac{\partial A_\phi}{\partial\phi}+\frac{A_s}{s}+\frac{\partial A_z}{\partial z} = \left(\frac{\partial A_s}{\partial s}+\frac{A_s}{s}\right)+\frac{1}{s}\frac{\partial A_\phi}{\partial\phi}+\frac{\partial A_z}{\partial z}\\
&= \frac{1}{s}\frac{\partial}{\partial s}(A_s s)+\frac{1}{s}\frac{\partial A_\phi}{\partial\phi}+\frac{\partial A_z}{\partial z}
\end{aligned}
$$

$$
\begin{aligned}
\nabla\times\vec{A} &= \left(\frac{\partial}{\partial s}\hat{s}+\frac{1}{s}\frac{\partial}{\partial\phi}+\frac{\partial}{\partial z}\hat{z}\right)\times\vec{A} = \hat{s}\times\frac{\partial\vec{A}}{\partial s}+\frac{1}{s}\hat{\phi}\times\frac{\partial\vec{A}}{\partial\phi}+\hat{z}\times\frac{\partial\vec{A}}{\partial z}\\
&= \hat{s}\times\left(\frac{\partial A_s}{\partial s}\hat{s}+\frac{\partial A_\phi}{\partial s}\hat{\phi}+\frac{\partial A_z}{\partial s}\hat{z}+A_s\cancelto{0}{\frac{\partial\hat{s}}{\partial s}}+A_\phi\cancelto{0}{\frac{\partial\hat{\phi}}{\partial s}}+A_z\cancelto{0}{\frac{\partial\hat{z}}{\partial s}}\right)+\\
&\quad \frac{\hat{\phi}}{s}\times\left(\frac{\partial A_s}{\partial\phi}\hat{s}+\frac{\partial A_\phi}{\partial\phi}\hat{\phi}+\frac{\partial A_z}{\partial\phi}\hat{z}+A_s\cancelto{\hat{\phi}}{\frac{\partial\hat{s}}{\partial\phi}}+A_\phi\cancelto{\hat{s}}{\frac{\partial\hat{\phi}}{\partial\phi}}+A_z\cancelto{0}{\frac{\partial\hat{z}}{\partial\phi}}\right)+\\
&\quad \hat{z}\times\left(\frac{\partial A_s}{\partial z}\hat{s}+\frac{\partial A_\phi}{\partial z}\hat{\phi}+\frac{\partial A_z}{\partial z}\hat{z}+A_s\cancelto{0}{\frac{\partial\hat{s}}{\partial z}}+A_\phi\cancelto{0}{\frac{\partial\hat{\phi}}{\partial z}}+A_z\cancelto{0}{\frac{\partial\hat{z}}{\partial z}}\right)\\
&= \frac{\partial A_\phi}{\partial s}\hat{z}-\frac{\partial A_z}{\partial s}\hat{\phi}-\frac{1}{s}\frac{\partial A_s}{\partial\phi}\hat{z}+\frac{1}{s}\frac{\partial A_z}{\partial\phi}\hat{s}+\frac{1}{s}A_\phi\hat{z}+\frac{\partial A_s}{\partial z}\hat{s}-\frac{\partial A_\phi}{\partial z}\hat{s}\\
&= \left(\frac{1}{s}\frac{\partial A_z}{\partial\phi}-\frac{\partial A_\phi}{\partial z}\right)\hat{s}+\left(\frac{\partial A_s}{\partial z}-\frac{\partial A_z}{\partial s}\right)\hat{s}+\left(\frac{\partial A_\phi}{\partial s}+\frac{A_\phi}{s}-\frac{1}{s}\frac{\partial A_s}{\partial\phi}\right)\hat{z}\\
&= \left(\frac{1}{s}\frac{\partial A_z}{\partial\phi}-\frac{\partial A_\phi}{\partial z}\right)\hat{s}+\left(\frac{\partial A_s}{\partial z}-\frac{\partial A_z}{\partial s}\right)\hat{s}+\frac{1}{s}\frac{\partial}{\partial s}(A_\phi s)-\frac{1}{s}\frac{\partial A_s}{\partial\phi}
\end{aligned}
$$

$$
\begin{aligned}
\nabla^2 u &= \hat{s}\cdot\left(\hat{s}\frac{\partial^2 u}{\partial s^2}-\frac{\hat{\phi}}{s^2}\frac{\partial u}{\partial\phi}+\frac{\hat{\phi}}{s}\frac{\partial^2 u}{\partial\phi\partial s}+\hat{z}\frac{\partial^2 u}{\partial z\partial s}\right)+\\
&\quad \frac{\hat{\phi}}{s}\cdot\left(\hat{\phi}\frac{\partial u}{\partial s}+\hat{s}\frac{\partial^2 u}{\partial s\partial\phi}-\frac{\hat{s}}{s}\frac{\partial u}{\partial\phi}+\frac{\hat{\phi}}{s}\frac{\partial^2 u}{\partial\phi^2}+\hat{z}\frac{\partial^2 u}{\partial z\partial\phi}\right)+\\
&\quad \hat{z}\cdot\left(\hat{s}\frac{\partial^2 u}{\partial s\partial z}+\frac{\hat{\phi}}{s}\frac{\partial^2 u}{\partial\phi\partial z}+\hat{z}\frac{\partial^2 u}{\partial z^2}\right)\\
&= \frac{\partial^2 u}{\partial s^2}+\frac{1}{s}\frac{\partial u}{\partial s}+\frac{1}{s^2}\frac{\partial^2 u}{\partial\phi^2}+\frac{\partial^2 u}{\partial z^2}\\
&= \frac{1}{s}\frac{\partial}{\partial s}\left(s\frac{\partial u}{\partial s}\right)+\frac{1}{s^2}\frac{\partial^2 u}{\partial\phi^2}+\frac{\partial^2 u}{\partial z^2}\\
\nabla^2 &\equiv \frac{1}{s}\frac{\partial}{\partial s}\left(s\frac{\partial}{\partial s}\right)+\frac{1}{s^2}\frac{\partial^2}{\partial\phi^2}+\frac{\partial^2}{\partial z^2}
\end{aligned}
$$

$\vec r = x\hat x + y\hat y + z\hat z$

$= r\sin\theta\cos\phi\,\hat x + r\sin\theta\sin\phi\,\hat y + r\cos\theta\,\hat z$ $\quad \hat r = \dfrac{\frac{\partial\vec r}{\partial r}}{\left|\frac{\partial\vec r}{\partial r}\right|} =$

$\dfrac{\partial\vec r}{\partial r} = \sin\theta\cos\phi\,\hat x + \sin\theta\sin\phi\,\hat y + \cos\theta\,\hat z$

$\left|\dfrac{\partial\vec r}{\partial r}\right|^2 = 1$

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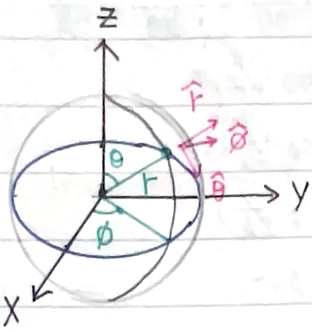
Spherical Coordinates

$dV = dr\ r\,d\theta\ r\sin\theta\,d\phi$



$x = r\sin\theta\cos\phi \qquad r = \sqrt{x^2+y^2+z^2}$

$y = r\sin\theta\sin\phi \qquad \tan\theta = \dfrac{\sqrt{x^2+y^2}}{z}$

$z = r\cos\theta \qquad \tan\phi = \dfrac{y}{x}$

$\hat r = \dfrac{\vec r}{r} = \dfrac{x\hat x + y\hat y + z\hat z}{r} = \hat x\sin\theta\cos\phi + \hat y\sin\theta\sin\phi + \hat z\cos\theta$

$\hat\phi = \dfrac{\hat z\times\hat r}{\sin\theta} = -\hat x\sin\phi + \hat y\cos\phi$

$\hat\theta = \hat\phi\times\hat r = \hat x\cos\theta\cos\phi + \hat y\cos\theta\sin\phi - \hat z\sin\theta$

$\dfrac{\partial\hat r}{\partial r} = 0$

$\dfrac{\partial\hat r}{\partial\theta} = \hat x\cos\theta\cos\phi + \hat y\cos\theta\sin\phi - \hat z\sin\theta = \hat\theta$

$\dfrac{\partial\hat r}{\partial\phi} = -\hat x\sin\theta\sin\phi + \hat y\sin\theta\cos\phi$

$= (-\hat x\sin\phi + \hat y\cos\phi)\sin\theta$

$= \hat\phi\sin\theta$

$\dfrac{\partial\hat\phi}{\partial r} = 0$

$\dfrac{\partial\hat\phi}{\partial\theta} = 0$

$\dfrac{\partial\hat\phi}{\partial\phi} = -\hat x\cos\phi - \hat y\sin\phi$

$= -(\hat r\sin\theta + \hat\theta\cos\theta)$

$\dfrac{\partial\hat\theta}{\partial r} = 0$

$\dfrac{\partial\hat\theta}{\partial\theta} = -\hat x\sin\theta - \hat y\sin\theta\sin\phi - \hat z\cos\theta = -\hat r$

$\dfrac{\partial\hat\theta}{\partial\phi} = -\hat x\cos\theta\sin\phi + \hat y\cos\theta\cos\phi$

$= \hat\phi\cos\theta$

$$d\vec r = d(r\hat r) = \hat r\,dr + r\,d\hat r = \hat r\,dr + r\Big(\frac{\partial\hat r}{\partial r}dr + \underbrace{\frac{\partial\hat r}{\partial\theta}}_{\hat\theta}d\theta + \underbrace{\frac{\partial\hat r}{\partial\phi}}_{\hat\phi\sin\theta}d\phi\Big) = \hat r\,dr + \hat\theta\,r\,d\theta + \hat\phi\,r\sin\theta\,d\phi$$

$$du = \nabla u\cdot d\vec r = \frac{\partial u}{\partial r}dr + \frac{\partial u}{\partial\theta}d\theta + \frac{\partial u}{\partial\phi}d\phi = \underbrace{(\nabla u)_r}_{\frac{\partial u}{\partial r}}dr + \underbrace{(\nabla u)_\theta}_{\frac{1}{r}\frac{\partial u}{\partial\theta}}r\,d\theta + \underbrace{(\nabla u)_\phi}_{\frac{1}{r\sin\theta}\frac{\partial u}{\partial\phi}}r\sin\theta\,d\phi$$

$$\nabla \equiv \hat r\frac{\partial}{\partial r} + \frac{\hat\theta}{r}\frac{\partial}{\partial\theta} + \frac{\hat\phi}{r\sin\theta}\frac{\partial}{\partial\phi}$$

$$\nabla\cdot\vec A = \Big(\hat r\frac{\partial}{\partial r} + \frac{\hat\theta}{r}\frac{\partial}{\partial\theta} + \frac{\hat\phi}{r\sin\theta}\frac{\partial}{\partial\phi}\Big)\cdot\vec A = \hat r\cdot\frac{\partial\vec A}{\partial r} + \frac{\hat\theta}{r}\cdot\frac{\partial\vec A}{\partial\theta} + \frac{\hat\phi}{r\sin\theta}\cdot\frac{\partial\vec A}{\partial\phi}$$

$$= \hat r\cdot\Big(\frac{\partial A_r}{\partial r}\hat r + \frac{\partial A_\theta}{\partial r}\hat\theta + \frac{\partial A_\phi}{\partial r}\hat\phi + A_r\cancelto{0}{\frac{\partial\hat r}{\partial r}} + A_\theta\cancelto{0}{\frac{\partial\hat\theta}{\partial r}} + A_\phi\cancelto{0}{\frac{\partial\hat\phi}{\partial r}}\Big) +$$

$$\frac{\hat\theta}{r}\cdot\Big(\frac{\partial A_r}{\partial\theta}\hat r + \frac{\partial A_\theta}{\partial\theta}\hat\theta + \frac{\partial A_\phi}{\partial\theta}\hat\phi + A_r\cancelto{\hat\theta}{\frac{\partial\hat r}{\partial\theta}} + A_\theta\cancelto{-\hat r}{\frac{\partial\hat\theta}{\partial\theta}} + A_\phi\cancelto{0}{\frac{\partial\hat\phi}{\partial\theta}}\Big) +$$

$$\frac{\hat\phi}{r\sin\theta}\cdot\Big(\frac{\partial A_r}{\partial\phi}\hat r + \frac{\partial A_\theta}{\partial\phi}\hat\theta + \frac{\partial A_\phi}{\partial\phi}\hat\phi + A_r\cancelto{\sin\theta\hat\phi}{\frac{\partial\hat r}{\partial\phi}} + A_\theta\cancelto{\cos\theta\hat\phi}{\frac{\partial\hat\theta}{\partial\phi}} + A_\phi\cancelto{-(\hat r\sin\theta+\hat\theta\cos\theta)}{\frac{\partial\hat\phi}{\partial\phi}}\Big)$$

$$= \frac{\partial A_r}{\partial r} + \Big(\frac{1}{r}\frac{\partial A_\theta}{\partial\theta} + \frac{A_r}{r}\Big) + \Big(\frac{1}{r\sin\theta}\frac{\partial A_\phi}{\partial\phi} + \frac{A_r}{r} + \frac{A_\theta\cos\theta}{r\sin\theta}\Big)$$

$$= \Big(\frac{\partial A_r}{\partial r} + 2\frac{A_r}{r}\Big) + \Big(\frac{1}{r}\frac{\partial A_\theta}{\partial\theta} + \frac{A_\theta\cos\theta}{r\sin\theta}\Big) + \frac{1}{r\sin\theta}\frac{\partial A_\phi}{\partial\phi}$$

$$\nabla\cdot\vec A \equiv \frac{1}{r^2}\frac{\partial}{\partial r}(r^2 A_r) + \frac{1}{r\sin\theta}\frac{\partial}{\partial\theta}(A_\theta\sin\theta) + \frac{1}{r\sin\theta}\frac{\partial A_\phi}{\partial\phi}$$

$$\nabla\times\vec{A}=\left(\hat{r}\frac{\partial}{\partial r}+\frac{\hat{\theta}}{r}\frac{\partial}{\partial\theta}+\frac{\hat{\phi}}{r\sin\theta}\frac{\partial}{\partial\phi}\right)\times\vec{A}=\hat{r}\times\frac{\partial\vec{A}}{\partial r}+\frac{\hat{\theta}}{r}\times\frac{\partial\vec{A}}{\partial\theta}+\frac{\hat{\phi}}{r\sin\theta}\times\frac{\partial\vec{A}}{\partial\phi}$$

$$=\hat{r}\times\left(\frac{\partial A_r}{\partial r}\hat{r}+\frac{\partial A_\theta}{\partial r}\hat{\theta}+\frac{\partial A_\phi}{\partial r}\hat{\phi}+A_r\cancelto{0}{\frac{\partial\hat{r}}{\partial r}}+A_\theta\cancelto{0}{\frac{\partial\hat{\theta}}{\partial r}}+A_\phi\cancelto{0}{\frac{\partial\hat{\phi}}{\partial r}}\right)+$$

$$\frac{\hat{\theta}}{r}\times\left(\frac{\partial A_r}{\partial\theta}\hat{r}+\frac{\partial A_\theta}{\partial\theta}\hat{\theta}+\frac{\partial A_\phi}{\partial\theta}\hat{\phi}+A_r\cancelto{\hat{\theta}}{\frac{\partial\hat{r}}{\partial\theta}}+A_\theta\cancelto{-\hat{r}}{\frac{\partial\hat{\theta}}{\partial\theta}}+A_\phi\cancelto{0}{\frac{\partial\hat{\phi}}{\partial\theta}}\right)+$$

$$\frac{\hat{\theta}}{r\sin\theta}\times\left(\frac{\partial A_r}{\partial\phi}\hat{r}+\frac{\partial A_\theta}{\partial\phi}\theta+\frac{\partial A_\phi}{\partial\phi}\hat{\phi}+A_r\cancelto{\sin\theta\hat{\phi}}{\frac{\partial\hat{r}}{\partial\phi}}+A_\theta\cancelto{\cos\theta\hat{\phi}}{\frac{\partial\hat{\theta}}{\partial\phi}}+A_\phi\cancelto{-(\hat{r}\sin\theta+\hat{\theta}\cos\theta)}{\frac{\partial\hat{\theta}}{\partial\phi}}\right)$$

$$=\left(\frac{\partial A_\theta}{\partial r}\hat{\phi}-\frac{\partial A_\phi}{\partial r}\hat{\theta}\right)+\left(-\frac{1}{r}\frac{\partial A_r}{\partial\theta}\hat{\phi}+\frac{1}{r}\frac{\partial A_\phi}{\partial\theta}\hat{r}+\frac{A_\theta}{r}\hat{\phi}\right)+$$

$$\left(\frac{1}{r\sin\theta}\frac{\partial A_r}{\partial\phi}\hat{\theta}-\frac{1}{r\sin\theta}\frac{\partial A_\theta}{\partial\phi}-\frac{A_\phi\cos\theta}{r\sin\theta}\right)$$

$$=\hat{r}\left(\frac{1}{r}\frac{\partial A_\phi}{\partial\theta}-\frac{1}{r\sin\theta}\frac{\partial A_\theta}{\partial\phi}+\frac{A_\phi\cos\theta}{r\sin\theta}\right)+\hat{\theta}\left(-\frac{\partial A_\phi}{\partial r}+\frac{1}{r\sin\theta}\frac{\partial A_r}{\partial\phi}-\frac{A_\phi}{r}\right)+\hat{\phi}\left(\frac{\partial A_\theta}{\partial r}-\frac{1}{r}\frac{\partial A_r}{\partial\theta}+\frac{A_\theta}{r}\right)$$

$$\nabla\times\vec{A}\equiv\frac{\hat{r}}{r\sin\theta}\left[\frac{\partial}{\partial\theta}(A_\phi\sin\theta)-\frac{\partial A_\phi}{\partial\phi}\right]+\frac{\hat{\theta}}{r\sin\theta}\left[\frac{\partial A_r}{\partial\phi}-\sin\theta\frac{\partial}{\partial r}(rA_\phi)\right]+\frac{\hat{\phi}}{r}\left[\frac{\partial}{\partial r}(rA_\theta)-\frac{\partial A_r}{\partial\theta}\right]$$

$$\nabla^2u=\left(\hat{r}\frac{\partial}{\partial r}+\frac{\hat{\theta}}{r}\frac{\partial}{\partial\theta}+\frac{\hat{\phi}}{r\sin\theta}\frac{\partial}{\partial\phi}\right)\cdot\left(\hat{r}\frac{\partial u}{\partial r}+\frac{\hat{\theta}}{r}\frac{\partial u}{\partial\theta}+\frac{\hat{\phi}}{r\sin\theta}\frac{\partial u}{\partial\phi}\right)$$

$$=\hat{r}\cdot\frac{\partial}{\partial r}\left(\hat{r}\frac{\partial u}{\partial r}+\frac{\hat{\theta}}{r}\frac{\partial u}{\partial\theta}+\frac{\hat{\phi}}{r\sin\theta}\frac{\partial u}{\partial\phi}\right)+\frac{\hat{\theta}}{r}\cdot\frac{\partial}{\partial\theta}\left(\hat{r}\frac{\partial u}{\partial r}+\frac{\hat{\theta}}{r}\frac{\partial u}{\partial\theta}+\frac{\hat{\phi}}{r\sin\theta}\frac{\partial u}{\partial\phi}\right)+$$

$$\left(\frac{\hat{\phi}}{r\sin\theta}\frac{\partial}{\partial\phi}\hat{r}\frac{\partial u}{\partial r}+\frac{\hat{\theta}}{r}\frac{\partial u}{\partial\theta}+\frac{\hat{\phi}}{r\sin\theta}\frac{\partial u}{\partial\phi}\right)$$

$$=\hat{r}\cdot\left(\hat{r}\frac{\partial^2u}{\partial r^2}-\frac{\hat{\theta}}{r^2}\frac{\partial u}{\partial\theta}+\frac{\hat{\theta}}{r}\frac{\partial^2u}{\partial\theta\partial r}-\frac{\hat{\phi}}{r^2\sin\theta}\frac{\partial u}{\partial\phi}+\frac{\hat{\phi}}{r\sin\theta}\frac{\partial^2u}{\partial\phi\partial r}\right)+$$

$$\frac{\hat{\theta}}{r}\cdot\left(\hat{\theta}\frac{\partial u}{\partial r}+\hat{r}\frac{\partial^2u}{\partial r\partial\theta}-\frac{\hat{r}}{r}\frac{\partial u}{\partial\theta}+\frac{\hat{\theta}}{r}\frac{\partial^2u}{\partial\theta^2}-\frac{\hat{\phi}\cos\theta}{r\sin^2\theta}\frac{\partial u}{\partial\phi}+\frac{\hat{\phi}}{r\sin\theta}\frac{\partial^2u}{\partial\phi\partial\theta}\right)+$$

$$\frac{\hat{\phi}}{r\sin\theta}\left(\hat{\phi}\sin\theta\frac{\partial u}{\partial r}+\hat{r}\frac{\partial^2u}{\partial r\partial\phi}+\frac{\hat{\phi}\cos\theta}{r}\frac{\partial u}{\partial\theta}+\frac{\hat{\theta}}{r}\frac{\partial^2u}{\partial\theta\partial\phi}-\frac{\hat{r}\sin\theta+\hat{\theta}\cos\theta}{r\sin\theta}\frac{\partial u}{\partial\phi}+\frac{\hat{\phi}}{r\sin\theta}\frac{\partial^2u}{\partial\phi^2}\right)$$

$$=\left(\frac{\partial^2u}{\partial r^2}\right)+\left(\frac{1}{r}\frac{\partial u}{\partial r}+\frac{1}{r^2}\frac{\partial^2u}{\partial\theta^2}\right)-\left(\frac{1}{r}\frac{\partial u}{\partial r}+\frac{\cos\theta}{r^2\sin\theta}\frac{\partial u}{\partial\theta}+\frac{1}{r^2\sin^2\theta}\frac{\partial^2u}{\partial\phi^2}\right)$$

$$=\left(\frac{\partial^2u}{\partial r^2}+\frac{2}{r}\frac{\partial u}{\partial r}\right)+\left(\frac{1}{r^2}\frac{\partial^2u}{\partial\theta^2}-\frac{\cos\theta}{r^2\sin\theta}\frac{\partial u}{\partial\theta}\right)-\left(\frac{1}{r^2\sin^2\theta}\frac{\partial^2u}{\partial\phi^2}\right)$$

$$=\frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial u}{\partial r}\right)+\frac{1}{r^2\sin\theta}\frac{\partial}{\partial\theta}\left(\sin\theta\frac{\partial u}{\partial\theta}\right)+\frac{1}{r^2\sin^2\theta}\frac{\partial^2u}{\partial\phi^2}$$

$$\nabla^2\equiv\frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial}{\partial r}\right)+\frac{1}{r^2\sin\theta}\frac{\partial}{\partial\theta}\left(\sin\theta\frac{\partial}{\partial\theta}\right)+\frac{1}{r^2\sin^2\theta}\frac{\partial^2}{\partial\phi^2}$$