PHYS 410 Homework # 8

6.1 On a spherical surface, the longitude and latitude lines are orthogonal.

For a small change in position, we have the change in longitude and latitude:

$$dl_{lo} = R\cdot d\theta \quad , \quad dl_{la} = R\cdot \sin\theta \cdot d\phi$$

$$\Rightarrow ds = \sqrt{dl_{lo}^2 + dl_{la}^2} = R\,d\theta\sqrt{1+\sin^2\theta\left(\frac{d\phi}{d\theta}\right)^2}$$

$$\Rightarrow L = \int_{P_1}^{P_2} ds = R\int_{\theta_1}^{\theta_2}\sqrt{1+\sin^2\theta\left(\frac{d\phi}{d\theta}\right)^2}\cdot d\theta$$

6.3

$$L = \overline{P_1Q} + \overline{QP_2} = \sqrt{x^2+y^2+z^2} + \sqrt{(x_2-x)^2+y_2^2+z^2}$$

$$\Rightarrow T = L/c$$

According to Fermat's principle, we get:

$$\frac{\partial T}{\partial x} = 0 \quad , \quad \frac{\partial T}{\partial z} = 0.$$

$$\frac{\partial T}{\partial z} = 0 \Rightarrow z\cdot\left(\frac{1}{\sqrt{x^2+y^2+z^2}} + \frac{1}{\sqrt{(x_2-x)^2+y_2^2+z^2}}\right) = 0 \Rightarrow z = 0 \qquad -(1)$$

$$\frac{\partial T}{\partial x} = 0 \Rightarrow \frac{x}{\sqrt{x^2+y^2+z^2}} + \frac{x-x_2}{\sqrt{(x_2-x)^2+y_2^2+z^2}} = 0 \qquad -(2)$$

According to (1), when $z=0$, we get from (2):

$$\sin\theta_1 = \sin\theta_2$$

$$\Rightarrow \theta_1 = \theta_2$$

6.5

According to General Geometric relation, we know $\angle APB = \frac{\pi}{2}$.

And $\alpha = \frac{\pi-\theta}{2}$

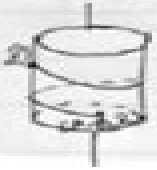
$$\Rightarrow AP = AB\cdot\sin\left(\frac{\pi}{2}-\alpha\right) = AB\cos\frac{\theta}{2} = AB\sin\frac{\theta}{2} = 2R\sin\frac{\theta}{2}$$

$$BP = AB\cdot\sin\alpha = 2R\cdot\cos\frac{\theta}{2}$$

$$\Rightarrow AP+BP = 2R\left(\sin\frac{\theta}{2}+\cos\frac{\theta}{2}\right) = 2\sqrt{2}\sin\left(\frac{\theta}{2}+\frac{\pi}{4}\right)R$$

$$\Rightarrow (AP+BP)_{max} = 2\sqrt{2}R \quad \text{when } \theta = \frac{\pi}{2}, \text{ which is the real part.}$$

6.7



In cylinder coordinates, when R is const, the infinitesimal change in position corresponds to $dl = \sqrt{R^2d\theta^2+(dz)^2} = dz\sqrt{1+R^2\theta'^2(z)} = f(\theta', z)\,dz$

$$\Rightarrow L = \int_{P_1}^{P_2} dl = \int_{z_1}^{z_2} f(\theta', z)\,dz$$

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