

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:

$$ds_{\theta} = R \cdot d\theta, \quad ds_{\phi} = R \sin\theta \cdot d\phi$$

$$\Rightarrow ds = \sqrt{ds_{\theta}^2 + ds_{\phi}^2} = R \cdot d\theta \sqrt{1 + \sin^2\theta \frac{d\phi^2}{d\theta^2}}$$

$$\Rightarrow L = \int_{\theta_1}^{\theta_2} ds = R \int_{\theta_1}^{\theta_2} \sqrt{1 + \sin^2\theta \frac{d\phi^2}{d\theta^2}} \cdot d\theta$$

6.3



$$L(P, Q) = \sqrt{x_1^2 + y_1^2 + z_1^2} + \sqrt{x_2^2 + y_2^2 + z_2^2}$$

$$\Rightarrow T = L/c$$

According to Fermat's principle, we get:

$$\frac{\delta T}{\delta x} = 0, \quad \frac{\delta T}{\delta y} = 0.$$

$$\frac{\delta T}{\delta z} = 0 \Rightarrow 2 \cdot \left(\frac{1}{\sqrt{x_1^2 + y_1^2 + z_1^2}} + \frac{1}{\sqrt{x_2^2 + y_2^2 + z_2^2}} \right) = 0 \Rightarrow z = 0 \quad (1)$$

$$\frac{\delta T}{\delta x} = 0 \Rightarrow \frac{x_1}{\sqrt{x_1^2 + y_1^2 + z_1^2}} + \frac{x_2}{\sqrt{x_2^2 + y_2^2 + z_2^2}} = 0 \quad (2)$$



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 $\angle APB = \frac{\theta}{2}$.

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

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

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

$$\Rightarrow APB = 2R \cdot (\sin \frac{\theta}{2} + \cos \frac{\theta}{2}) = 2\sqrt{2} \sin(\frac{\theta}{2} + \frac{\pi}{4}) R$$

$$\Rightarrow (APB)_{max} = 2\sqrt{2} R \text{ when } \theta = \frac{\pi}{2}, \text{ which is the real path.}$$

6.7

(2.4.2)



In cylinder coordinates, when R is const, the infinitesimal change in position corresponds to

$$ds = \sqrt{R^2 d\phi^2 + dz^2} = dz \sqrt{1 + R^2 \frac{d\phi^2}{dz^2}} = f(\phi, z) dz$$

$$\Rightarrow L = \int_{\phi_1}^{\phi_2} ds = \int_{z_1}^{z_2} f(\phi, z) dz$$

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