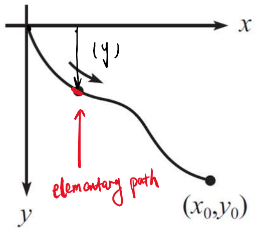

$$mg \cdot y = \frac{1}{2} m v^2 \qquad v = \sqrt{2gy}$$

$$\star \quad dt = \frac{dl}{v} = \frac{\sqrt{(dx)^2 + (dy)^2}}{\sqrt{2gy}} = \frac{\sqrt{1 + \left(\frac{dy}{dx}\right)^2}}{\sqrt{2gy}} dx$$

$$= \frac{\sqrt{1 + y'^2}}{\sqrt{2gy}} dx$$

Stationary point $\boxed{\frac{\partial S}{\partial x} = 0}$

$$\boxed{\frac{\partial T}{\partial x_i} = 0}$$

$$T = \int_0^{x_0} \frac{\sqrt{1 + y'^2}}{\sqrt{2gy}} dx$$

dx, dy, dl

$$\star \quad \text{“} L \text{”} \propto \frac{\sqrt{1 + y'^2}}{\sqrt{y}} \qquad \text{Action} \quad S \equiv \int_0^t L \, dt$$

Euler–Lagrange Equation

$$f(y) = \frac{1}{\sqrt{y}} \qquad L = \sqrt{1 + y'^2} \cdot f(y)$$

$$\frac{df}{dx} = \frac{df}{dy} \cdot \frac{dy}{dx} = \frac{df}{dy} \cdot y' = -\frac{1}{2} \cdot \frac{1}{y^{\frac{3}{2}}}$$

$$\Rightarrow \quad 1 + y'^2 = B \cdot f^2(y) \qquad \boxed{1 + y'^2 = \frac{B}{y}}$$

$$\left(\frac{dy}{dx}\right)^2 = \frac{B}{y} - 1 = \frac{B - y}{y} \qquad \frac{dy}{dx} = \pm \sqrt{\frac{B - y}{y}}$$

$$\frac{\sqrt{y}\, dy}{\sqrt{B - y}} = \pm dx \qquad y = B \sin^2 \varphi \qquad dy = 2B \sin\varphi \cos\varphi \, d\varphi$$

$$\frac{\sqrt{B} \sin\varphi}{\sqrt{B - B\sin^2\varphi}} \cdot 2B \sin\varphi \cancel{\cos\varphi} \, d\varphi = 2B \sin^2 \varphi \, d\varphi = \pm dx$$

$$\int 2B \sin^2 \varphi \, d\varphi = \int \pm dx = \pm x + C \qquad \cos 2\varphi = 1 - 2\sin^2\varphi \qquad 2\sin^2\varphi = 1 - \cos 2\varphi$$

$$\int B (1 - \cos 2\varphi) \, d\varphi = \pm x + C \qquad x = \pm a(\theta - \sin\theta) \pm d$$

$$y = a(1 - \cos\theta)$$

$$x = a(\theta - \sin\theta) \qquad y = a(1 - \cos\theta) \qquad (x_0, y_0) = (0, 0)$$

$$T = \int_0^{x_0} \boxed{\frac{\sqrt{1 + y'^2}}{\sqrt{y}}} \cdot \frac{1}{\sqrt{2g}} dx \qquad S \equiv \int_0^t L \, dt$$

$$\boxed{\frac{d}{dy}\left(\frac{\partial L}{\partial x'}\right) = \frac{\partial L}{\partial x}} \quad \text{E-L Equation.} \qquad \frac{d}{dt}\left(\frac{\partial L}{\partial \dot{x}}\right) = \frac{\partial L}{\partial x}$$

$$L(r, \dot{r}, \theta, \dot{\theta})$$

$$\frac{d}{dy}\left(\frac{1}{\sqrt{y}} \cdot \frac{x'}{\sqrt{1 + x'^2}}\right) = \frac{\partial L}{\partial x} = 0$$