$\int_0^{2\pi} \frac{d\phi}{1+\varepsilon\cos\phi}$ is a standard integral whose value works out to be

$$\frac{2\pi}{\sqrt{(1-\varepsilon^2)}}$$

$$\therefore \quad I = \frac{2\pi}{\sqrt{(1-\varepsilon^2)}} - 2\pi$$

Now, equation (2) can be written as

$$\frac{2\pi p_\phi}{\sqrt{(1-\varepsilon^2)}} - 2\pi p_\phi = n_r h$$

or

$$\frac{n_\phi h}{\sqrt{(1-\varepsilon^2)}} - n_\phi h = n_r h$$

$$\left[\text{Since } p_\phi = n_\phi \frac{h}{2\pi}\right]$$

$$\therefore \quad n_r = \frac{n_\phi}{\sqrt{(1-\varepsilon^2)}} - n_\phi$$

$$\text{or,} \quad n_r + n_\phi = \frac{n_\phi}{\sqrt{(1-\varepsilon^2)}}$$

But, $n_r + n_\phi = n$, the principal quantum number

Hence, $$n = \frac{n_\phi}{\sqrt{(1-\varepsilon^2)}}$$

$$1-\varepsilon^2 = \frac{n_\phi^2}{n^2}$$

For an ellipse $1-\varepsilon^2 = b^2/a^2$ where a and b are the semi-major and semi-minor axes respectively

$$\frac{b^2}{a^2} = \frac{n_\phi^2}{n^2}.$$

$$\text{or } \frac{b}{a} = \frac{n_\phi}{n}$$

$$\text{or, } \frac{b}{a} = \frac{k}{n}$$

Thus semimajor axis is governed by the principal qu. no. and semiminor axis is governed by both the n and k.