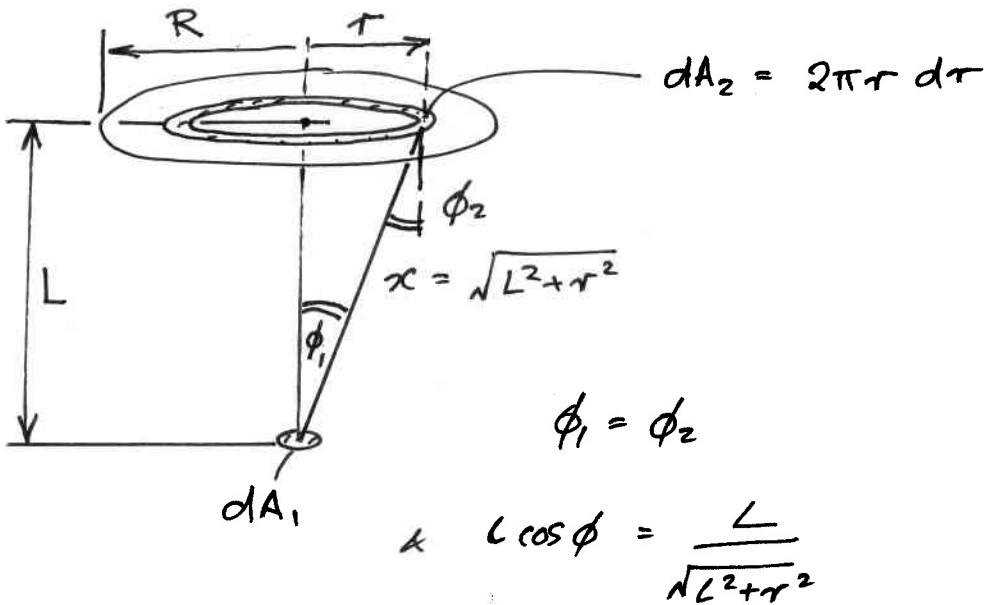


Qu. 3

$$F_{12} = \iint_{A_1, A_2} \frac{\cos \phi_1 \cos \phi_2 dA_1 dA_2}{\pi x^2}$$



Since $A_1 = dA_1$ the integral becomes

$$\begin{aligned} F_{12} &= \int_{A_2} \frac{\cos \phi_1 \cos \phi_2 dA_2}{\pi x^2} \\ &= \int_0^R \frac{\cos^2 \phi \cdot 2\pi r dr}{\pi (L^2 + r^2)} \\ &= \int_0^R \frac{2L^2 r}{(L^2 + r^2)^2} dr \end{aligned}$$

Substitute $u = L^2 + r^2$ then $du = 2r dr$

$$\therefore F_{12} = \int \frac{L^2 du}{u^2} = -\frac{L^2}{u}$$

$$\begin{aligned} \therefore F_{12} &= \left[-\frac{L^2}{L^2 + r^2} \right]_0^R = \frac{-L^2}{L^2 + R^2} - (-1) \\ &= \frac{-L^2 + L^2 + R^2}{L^2 + R^2} = \frac{R^2}{L^2 + R^2} \end{aligned}$$