[Cheng P.6-49] Assuming that the circular loop in Problem P.6-45 is rotated about its horizontal axis by an angle α, find the torque exerted on the circular loop.

Solution: Resolve the circular loop into many small loops, each with a magnetic dipole moment $d\mathbf{m} = I_2 d\mathbf{S}$, $d\tau = d\mathbf{m} \times \mathbf{B}$. Integrating these small loops

$$\mathbf{T} = \int d\tau$$

$$= I_2 \int d\mathbf{S} \times \mathbf{B}$$

$$= -\mathbf{a}_x I_2 \sin\alpha \int B dS$$

$$= -\mathbf{a}_x \mu_0 I_1 I_2 \left(d - \sqrt{d^2 - b^2} \right) \sin\alpha$$

where the last line is the result from Problem P.6-39.

This torque is in the direction of aligning the flux produced by I_2 in the loop with that of $\mathbf{B}$ due to I_1 in the straight wire.

Answer:

$$\mathbf{T} = -a_x \, \mu_o I_1 I_2 (d - \sqrt{d^2 - b^2}) \sin\alpha$$

This torque is in the direction of aligning the flux produced by I_2 in the loop with that of $\mathbf{B}$ due to I_1 in the straight wire.