Solution

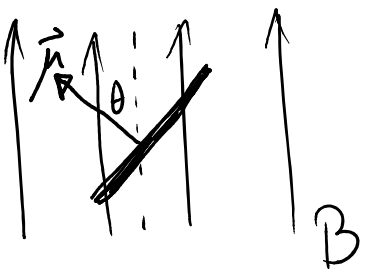
Let's first determine the magnetic field in the solenoid.

We have:

$$|\vec{B}| = \mu_0 I \cdot \frac{N}{L}$$

where $\mu_0 = 4\pi \times 10^{-7} \frac{Tm}{A}$ $I = 0.1A$, $N = 500$, $L = 0.03m$

So $|\vec{B}| = 2.09 \times 10^{-3} T$.



Now let's find the torque on the loop. The magnetic moment is:

$$|\vec{\mu}| = I \cdot A \cdot n$$
$$= (0.1A) \times (0.01m)^2 \cdot 50$$
$$= 5 \times 10^{-4} Am^2$$

When $\vec{\mu}$ is at an angle θ to $\vec{B}$, the torque is:

$$|\vec{\tau}| = |\vec{\mu} \times \vec{B}| = |\vec{\mu}||\vec{B}|\sin\theta$$
$$= (1.05 \times 10^{-6} Nm)|\sin\theta|$$

From this, we can get the time dependance of θ by: $\frac{d\theta}{dt} = \omega$, $\frac{d\omega}{dt} = \alpha = \frac{\tau}{I} = 1.05 s^{-2} |\sin\theta|$

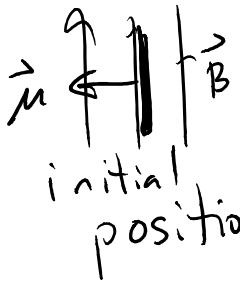
Note that we use $|\sin\theta|$ since the problem specifies that the current switches so that the torque is always in the same direction.

We now want to solve

$$\frac{d\omega}{dt} = (1.05\ s^{-2})\,|\sin\theta|$$

$$\frac{d\theta}{dt} = \omega$$

with $\theta(0) = \frac{\pi}{2}$ $\qquad$ $\omega(0) = 0.$



initial position.

Using Euler's method, we find that $\theta = \frac{\pi}{2} + 2\pi$ at $t \approx 4.02\ s$

EXPLICIT COMMANDS: Initially: $\theta = 3.1415/2$, $\omega = 0$

At each step:

$$\omega = \omega_{old} + \delta t \cdot \left[1.05 \cdot |\sin\theta_{old}|\right]$$

$$\theta = \theta_{old} + \delta t \left[\omega_{old}\right]$$

Run until $\theta = \frac{\pi}{2} + 2\pi$

OR: use $\frac{d\omega}{dt} = 1.05\cos\theta$ with $\theta(0) = 0$