496.

Problem 36.29 (RHK)

The armature of a motor has 97 *turns each of area* $190\ \text{cm}^2$ *and rotates in a uniform magnetic field of* $0.33\ \text{T}$. *A potential difference of* $24\ \text{V}$ *is applied. If no load is attached and friction is neglected, we have to find the rotational speed at equilibrium.*

Solution:

We will first find the expression for the induced emf assuming that a coil of area *A* and made of *n* turns is rotated uniformly in a magnetic field *B* with frequency ν.

Flux across the armature will be

$$\Phi = nAB\cos\theta,$$

And induced emf will be

$$\text{E} = -\frac{d\Phi}{dt} = nAB\omega\sin\theta(t),$$

$$\omega = \frac{d\theta}{dt} = 2\pi\nu,$$

and $\theta(t) = 2\pi\nu t.$

At equilibrium the induced emf has to be equal and opposite to the applied emf, so that there is no flow of current and there is no net force on the coil due to magnetic field.

We now use the data for finding thee frequency ν.

$n = 97,$

$A = 190 \times 10^{-4}\ \text{m}^2,$

$B = 0.33\ \text{T},$

and

$\text{E}_{motor} = 24\ \text{V}.$

Therefore,

$$\nu = \frac{24}{2\pi \times 190 \times 10^{-4} \times 97 \times 0.33}\ \text{rev s}^{-1} = 6.28\ \text{rev s}^{-1}.$$

The rotational speed at equilibrium will be 6.28 revolutions per second.