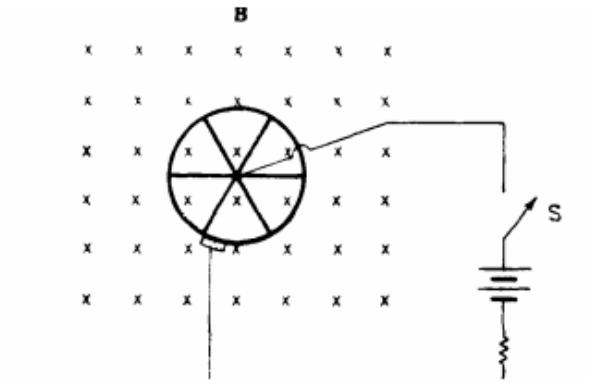
1. **The problem statement, all variables and given/known data**



1977E3. A wheel with six spokes is positioned perpendicular to a uniform magnetic field B of magnitude 0.5 tesla (weber per square meter). The field is directed into the plane of the paper and is present over the entire region of the wheel as shown above. When the switch S is closed, there is an initial current of 6 amperes between the axle and the rim, and the wheel begins to rotate. The resistance of the spokes and the rim may be neglected.

a. What is the direction of rotation of the wheel? Explain.
b. The radius of the wheel is 0.2 meters. Calculate the initial torque on the wheel.
c. Describe qualitatively the angular velocity of the wheel as a function of time.

Hello everyone. I am trying to solve this problem, and I am having some trouble understanding the solutions to the problem as shown below. If anyone could help me out please, that would be greatly appreciated. The solutions are as shown.

b) 7 points

$T = (N)(r)(BI\ell)$	for factor (N)	1
$= 0.06\ N \cdot m$	for factor ($r = 0.1m$)	2
	for factor ($BI\ell$)	2
	for the right combination of the factors	1
	for the answer with units	1

Alternate:

$F = I\ell B$	2
$= 6(.2)(.5) = .6N$	1
$\tau = Fr$	1
$= (.6N)(.1m)$	2
$= .06N \cdot m$	1

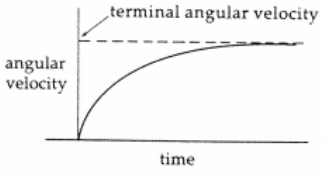
Alternate:

$F = I\ell B \sin\theta = I\ell B$	2
$\tau = \int_0^2 F\,d\ell = \int_0^2 IB\ell\,d\ell$	2
$= \frac{IB\ell^2}{2}\Big\vert_0^2 = \frac{6(.5)(.2)^2}{2}$	
$= .06\ N \cdot m$	1

c) 3 points

Angular velocity increases	1
Decreasing acceleration and/or explanation	1
Goes to a terminal angular velocity	1

Alternate:



2. Relevant equations

For part b, torque = r * F * sin(theta).

I also know that (final angular velocity w) = (initial angular velocity w) + (angular acceleration * t)

3. The attempt at a solution

I get why in part a there is going to be a counterclockwise rotation of the wheel. I do not need help with that.

In my work I did the following:

Torque due to one spoke of the wheel is going to be

r * F * sin 90degrees = 0.2 * (ILB) * 1 = 0.2 * (6*0.2*0.5) = 0.12 N-m

Then I said that because we have six spokes, with each torque on it being 0.12 N-m, then we need to multiply 0.12 by six to get the total torque being = 0.72 N-m.

My first question is why did they not multiply their original answer by six to get the total torque given that what they calculated in the solution can be considered to be the torque exerted by the magnetic force on a spoke of the wheel?

My second question is why did they in their solution to part b say that the moment arm of the wheel (the “r” in the equation) equal 0.1 meters (which is half the radius) instead of 0.2 meters, which is the whole radius? My guess is that they are trying to calculate the average torque exerted by the magnetic force, so they are trying to use the average moment arm, which in this case is 0.1 meters.

My third question is that in part c, they say that the angular velocity increases and approaches a constant terminal velocity. Why is this true?

My approach was this: I said that there is going to be a constant torque on the wheel, and thus, the wheel is always going to experience a constant angular acceleration, meaning that the angular velocity is going to be constantly increasing with a constant slope. Thus, it will not, as you see, approach a terminal angular velocity. So why did they say in the solutions that it would?

Thanks in advance for the help, and make it a great day!