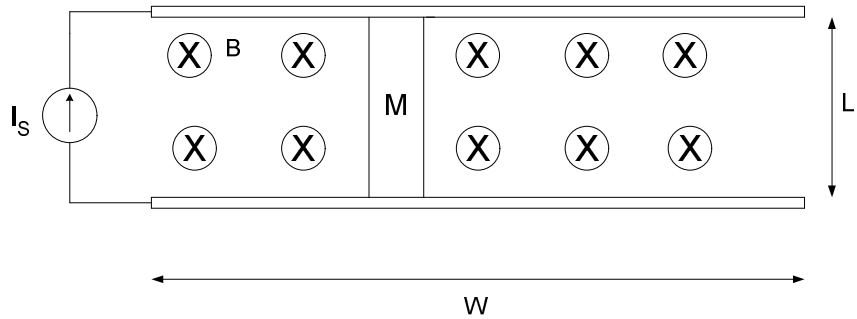
DC Motor Problems

1. Given the parameters for the following rail gun system: $L = 0.2m$, $W = 10m$, the mass of the movable member is $M = 20kg$, and the muzzle exit velocity is $2500\, m/s$ (initially at rest). Ignore the resistance of the rails and mechanical losses (friction and drag).



a. Determine the electromagnetic force required to accelerate the projectile to the specified exit velocity.

b. Calculate the required B-field to meet above specifications if the current source is providing 2.795×10^6 A.

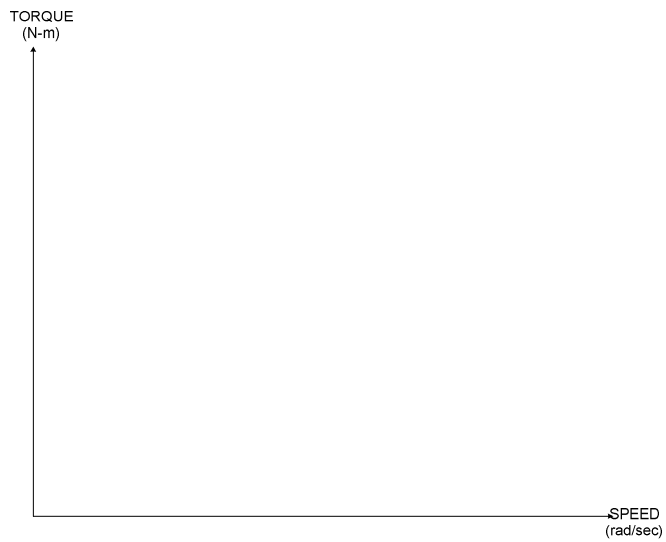
c. What is the peak value of back EMF while the projectile is in the barrel?

2. A 12V permanent magnet (PM) DC motor is operated unloaded where the armature current is 2.3A and speed is 1800rpm. The load is increased until the armature current equals to 20A. The motor in this loaded condition rotates at 1600rpm.

From the two operating conditions, determine the motor parameters R_a , K_v and τ_{loss} .

3. $12V_{DC}$ is applied to a permanent-magnet (PM) DC motor with armature resistance of 3Ω, and K_V of 0.2 V-s.

a. Draw the torque-vs-speed characteristic curve for this motor. Calculate and label the slope, maximum torque (y-intercept) and maximum speed (x-intercept).



b. If T_{loss} is negligible and $T_{load} = 430x10^{-6}\omega^2$, what is the steady state operating speed (in RPM) and the armature current?

c. Find the efficiency at this operating point.

4. A small permanent-magnet DC motor has an armature resistance of 2Ω. With a load attached and 12V DC applied, the motor draws 1A and operates at a speed of 1600rpm.

a. Determine the back EMF constant K_v

b. If the machine is 70% efficient, determine the torque delivered to the load (Hint: this is NOT the overall electromagnetic torque)

c. Calculate the loss torque

5. A Permanent Magnet (PM) DC motor is used in a car to raise and lower the window. With 12.6V applied, the motor draws 6A and turns at 800rpm while raising the window. When the motors *stops* (window completely raised), the motor draws 31.5A (the 12.6V still applied).

a. From the two operating conditions, determine the motor parameters R_a and K_v

b. If the motor is 75% efficient while raising the window, determine the rotational losses.