*** For practice, not collected or graded ***

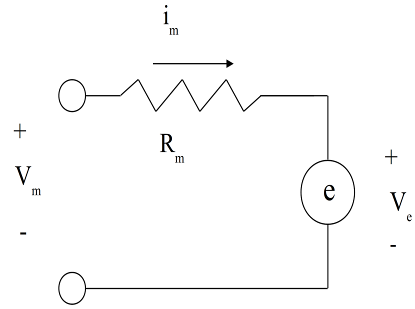

Fig. 1 Simplified motor model without inductance.
Given: $R_m = 2\Omega$, $k_\tau = 0.1Nm^{-1}$, $k_e = 0.01V - s/rad$

As derived in class, the motor torque depends on motor current: $\tau = k_\tau i_m$, where τ has units of $N - m$, and k_τ is $N - m/amp$.

The back emf voltage is proportional to motor velocity: $V_e = k_e \dot{\theta}_m$, where $\dot{\theta}_m$ is motor velocity in radians/second and thus k_e has units of $Volt - sec/rad$.

For the physics behind the motor model, see:
http://higheredbcs.wiley.com/legacy/college/nise/0470646128/appendices/appendixI.pdf

Problems:

1. The unloaded motor is connected to a 6V battery. Neglecting friction and other losses, determine i_m, V_e, and $\dot{\theta}_m$ in steady state.

2. The motor is connected to a 6V battery with negligible internal battery resistance. The motor shaft is clamped so that $\dot{\theta}_m = 0$.
Determine i_m, V_e, and τ_m.

3. The motor is connected through a gear box to a car tire. The motor is turning at 5000 rpm. What is the instantaneous open circuit voltage V_m?

4. The motor is turning at 5000 rpm, and V_m is now short circuited. What is the initial current i_m, and torque τ_m shortly after the short circuit is applied?

For the following, consider that the motor is connected through a gear box to a car tire. The motor is initially turning at 5000 rpm, and the car has inertia and friction.

5. Consider V_m is short circuited at $t = 0$. Sketch the trend of $i_m, V_e, \dot{\theta}_m$, and τ_m until the car comes to a rest.

6. Consider now V_m connected to battery at -1ms and short circuited for 2 ms at t=0. Sketch variables as above for -1 ms $< t <$ 2 ms.

7. Consider motor initially disconnected. Now V_m is connected to a 6V battery with negligible internal resistance at $t = 0$ ms. Sketch the trend of $i_m, V_e, \dot{\theta}_m$, and τ_m until the car reaches a steady state velocity.

8. Consider now V_m is connected to the 6V battery for 1 ms at t=0, and then V_m is open circuited. Sketch variables as above for -1 ms $< t <$ 2 ms.