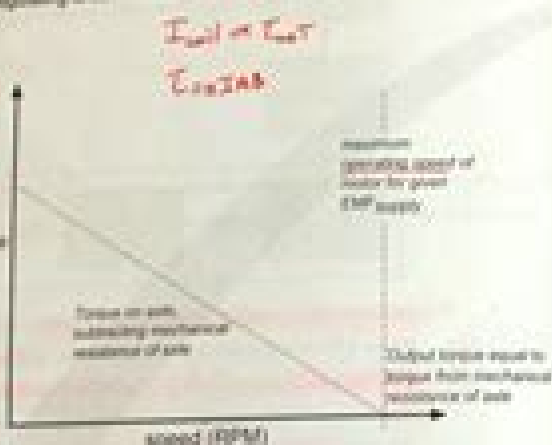
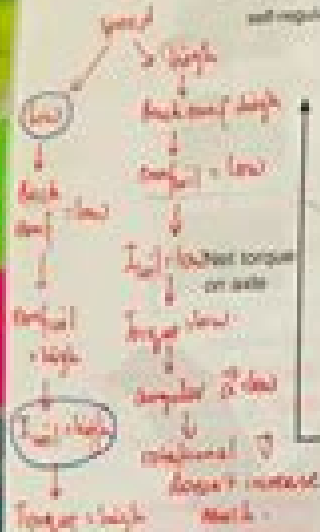


- The **effect of back EMF on current and torque is that:**
 - When a DC electric motor is first started, the **total EMF is high and low** (being flowing through the coil is high and equal to the supply voltage).
 - As the coil rotates faster, the back EMF increases, so the total current flowing through the motor is reduced.** (As the motor is in motion, due to mechanical resistance in the motor, the back EMF is never equal to, but always less than, the supply EMF).
 - The increase in total current with decrease in speed makes a motor self-regulating to some extent.



- Angular ω is high
↓
rotation speed increases
- When the motor is spinning at high revolutions, the back EMF is large and the current passing through the coil is small. Therefore the motor is protected from the risk of burnout.
- $$I = \frac{V}{R} \quad V \propto \omega \Rightarrow I \propto \frac{1}{\omega}$$
- However, a motor at start-up has no back EMF, so can draw too much current and overheat and burnout.
- $$V = IR \quad I = \frac{V}{R} \Rightarrow V \propto I$$
- To protect the motor on start-up, an adjustable starting resistor is placed in the circuit.
 - The resistor is removed when the motor's speed increases.

$$V=IR, I=\frac{V}{R}$$

Energy Transformations in DC Motor

- The mechanism of back EMF means that as electric motor drives into current and transfers energy at a slower rate
 - This is due to the decreased net torque at high rotor speeds, which results in a lower acceleration and kinetic energy increases at a slower rate
 - The motor's energy must come from the electrical supply. If it didn't it is just giving away energy, then the supply must be losing heat
- Consider an ideal motor with no friction. The energy transformation depends on rotation speed as summarised below

	Low speed	Maximum speed
Back EMF	Low	High (equal to supply EMF)
Total EMF	High	Zero
Total current		
Total torque		
Power from power supply ($P = VI$)		
Result	Coil accelerates	Coil rotates at constant speed
Energy transformation	Electrical energy is taken from the power supply and increases the mechanical energy of the coil	No energy taken from power supply Coil's mechanical energy remains constant

- Recall that torque is analogous to force
 - An object travels at **constant velocity when the net force is zero**
 - An object rotates at **constant speed when the net torque is zero**
- Note that the above is an ideal case - **in reality, there will be inefficiencies** such as friction in the motor that mean it will **never reach some constant rotational velocity**

↳ due to friction and heat loss

Is due to friction between
axel and rotating
(mechanical resistance of
the bearings, come from friction)

High School Physics Study Guide Answers

Robert R. Redfield



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