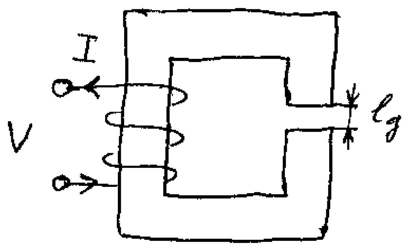
Problem 1 (20pts):

Consider the magnetic system shown below. Assume that reluctance of the core path and the air-gap are $\Re_c = 2\times10^5\ At/Wb$ and $\Re_g = 8\times10^5\ At/Wb$, respectively. The coil has 100 turns and dc resistance $r = 2\ \Omega$.

(a) (4pts) Assume the current direction as shown, draw an equivalent **magnetic** circuit, show the direction of mmf F and the flux Φ

(b) (4pts) Calculate the inductance L

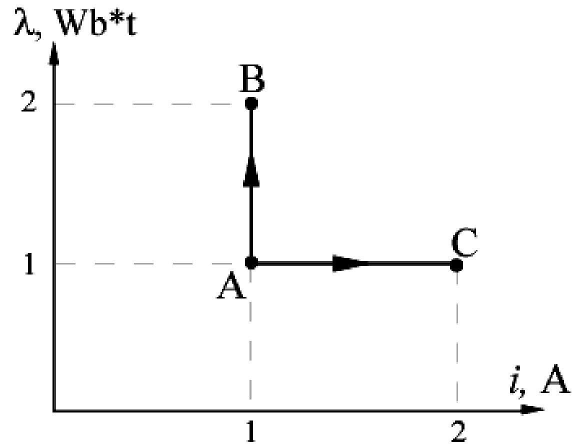
(c) (12pts) Assume that coil is connected to a 10V(rms) 60-Hz ac source. Calculate the rms values of current I, flux Φ, flux linkage λ.

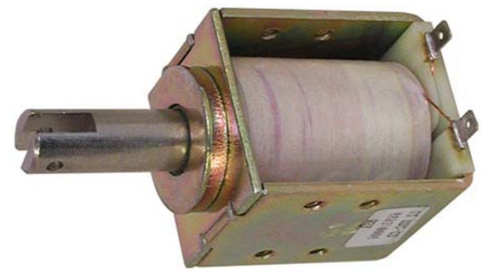


Problem 2 (20pts):

Assume an electromechanical system with one electrical and one mechanical inputs. The system may be assumed **magnetically linear** (similar to a solenoid). The system's state is shown in the $\lambda - i$ figure below, wherein the system can move from point A to point B, and from point A to point C, respectively. Using the numerical values given on this figure, **calculate the change in** W_f, W_c, W_e, and W_m for the two transitions. In other words, complete the Table given below. **Be sure to include the units and check the energy conversion balance!**

.





Transition	From A to B	From A to C
(3pts) Change in coupling field energy, ΔW_f		
(3pts) Change in co-energy, ΔW_c		
(3pts) Change in electrical input, ΔW_e		
(3pts) Change in mechanical input, ΔW_m		
(4pts) The energy was supplied to **(and how much)**		
(4pts) The energy was taken from **(and how much)**		

Problem 3 (20pts):

Assume that you have three identical 240/120V transformers. The transformers may be assumed ideal. These transformers are connected into Δ/Y to supply a $60\ \Omega$ (per-phase) Y-connected resistor load form a 120V (line-to-neutral) source.

(a) (10pts) Sketch the system and label the input (primary side) terminals with ***ABC*** and the load (output) terminals with ***abc***. Also label the voltages and currents including directions.

(b) (10pts) Calculate the currents I_A, I_{AB}, the voltages V_a, V_{ab}, the power supplied from the source P_{source}, and the power consumed by the load P_{load} (show that $P_{source} = P_{load}$).

Problem 4 (20pts):

A 60-Hz **step-up** transformer with $N_1 = 500$ and $N_2 = 1000$ has leakage reactances are $X_1 = 1.2\Omega$, $X_2 = 4\Omega$ (each referred to its own side), and the magnetizing reactance $X_m = 238.8\Omega$ (referred to the primary side). The core and copper losses can be neglected. Assume 120V is applied to the primary side:

(a) (10pts) Calculate the open-circuit primary current $I_{1,oc}$ and the secondary voltage $V_{2,oc}$ (their rms values)

(b) (10pts) Assume a resistive load $R_{Load} = 20\Omega$ is connected to the secondary side. Calculate the voltage regulation (VR). Also calculate the input (primary side) power-factor angle φ in degrees.

Problem 5 (20pts):

Consider a **Permanent-Magnet DC Motor** with the following parameters: rated/nominal voltage $V_t = 12\,\text{V}$; armature resistance $R_a = 1.2\,\Omega$. Under the NO-LOAD test the armature current is $I_{a\_nl} = 0.2\,\text{A}$ and the motor speed is $n_{nl} = 1800\,\text{rpm}$.

(a) (10pts) Calculate the induced armature emf E_{a_nl}, torque constant K_t, and the friction torque T_{fric}

(b) (10pts) Assume T_{fric} is constant (doesn't depend on speed). A mechanical load with the torque $T_m = 4 \cdot T_{fric}$ is connected to the motor shaft. Calculate the motor speed n in rpm and speed regulation *SR* in %

Problem 6 (20pts):

Consider a 115V **Separately-Excited DC Machine** with the armature resistance $R_a = 1\Omega$ and field-to-armature inductance $L_{af} = 0.111\,\text{H}$. The machine is supplied from a constant dc source $V_t = 115\,\text{V}$ and the shaft is connected to a mechanical system with constant speed $n = 1800\,\text{rpm}$ in CCW direction. Friction can be neglected.

(a) (4pts) Draw an equivalent circuit

(b) (8pts) The field current is set to $I_f = 5\,\text{A}$. Calculate the armature current I_a and torque T_e. Determine whether machine is motoring or generating. Is T_e in CW or **CCW** direction? (circle one)

(c) (8pts) The field current is increased to $I_f = 6\,\text{A}$. Calculate the armature current I_a and torque T_e. Determine whether machine is motoring or generating. Is T_e in **CW** or CCW direction? (circle one)

Problem 7 (20pts):

A DC shunt machine has $R_a = 0.25\ \Omega$. The machine is connected to a 250 V DC supply, draws armature current of 40 A, and rotates at 1200 rpm.

(a) Calculate the induced back emf E_a

(b) Determine the useful mechanical load torque T_m. The rotational losses are 100 W.

(c) Determine the efficiency of the motor η. The field circuit resistance is $R_f = 100\ \Omega$.