Kafrelsheikh University
Faculty of Engineering
Department: Electrical Engineering
Year : 2^{nd} year (2007) 2018-2019
Subject: Energy Conversion
Name: Dr. Amlak Abaza.

Date: 23 -5-2019.
Time Allowed: 3 hrs.
Full Mark: 90 Marks.
Final 2^{nd} Term Exam: 2 pages
Academic Code: EPM 2203.
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This Exam measures the ILOs [a.1, a.4,a.15, b.1, b.2, b.3, b.5, and c.1,c.2, c.3, and c.4]

Answer the Following Questions:

Question One: (25 Mark) [measures the ILOs of a.1, a.4, b.1, b.5, and c.1]

a) ***Derive*** the relationship between mutual inductance and self inductances of magnetically coupled two coils of N_1 and N_2 turns. [6Mark/a1.2]

b) With the aid of B-H relation of a non-linear magnetic material, ***show*** the effect of hysteresis in excitation current waveform. [7Mark/a.4.1 and b.1.1]

c) The device shown in the Fig. 2 is a practical form of magnet. It is cylindrical about a horizontal axis. The coil has 1300 turns and carries a constant current of 2.5 A. If the mmf in the iron is neglected. [12Mark/a.4.1,b.5.1, and c.1.1]

   i). ***Compute*** the flux densities, in Tesla, between the working faces of the center core and the plunger for gaps g=0.5, 1, and 2 cm.

   ii). ***Compute*** the corresponding values of the coil inductance, in henries.

   iii). ***Compute*** the energy stored in the magnetic field for each value of the air gap.

Question Two: (20 Mark) [measures the ILOs of a.4, b.5, c.1, c.2,c.3, and c.4]

a) In a doubly excited magnetically linear system with saliency associated with both the rotor and stator, ***derive*** an expression for the induced voltage in the system, ***explaining*** both motional and transformer induced voltages. [6Mark/ b.5.1]

b) Fig. 2 shows a magnetic circuit of iron of high permeability. Two air gaps each of length g and area A_g and a permanent magnet (PM) of length l_m and area A_m.

   i). ***Determine*** the necessary condition to minimize the volume of PM for a desired value of the flux density in the air gap.

   ii). If the maximum energy product occurs at B_m= 1.0 T and H_m = -40 kAT/m, ***Find*** the minimum magnet volume required to achieve an air-gap flux density of 0.8 T when the air gap dimensions are Ag = 2.0 cm^2 and g=0.2 cm. [8Mark/ b.5.1, c.1.1, and c.3.1]

c) For a linear translational electromechanical energy system, ***derive*** an expression for current, flux linkage and force in terms of stored energy and coenergy. [6Mark/ a.4.2, b.3.1, and c.1.1]

Question Three: (25 Mark) [measures the ILOs of a.1, a.4, a.15, b.2, b.3, and c.1, c.3]

a) ***Explain*** the operation conditions and construction of the salient-pole synchronous machine. [5Mark/a.1.1 and b.2]

b) Consider a doubly-excited system with cylindrical stator and salient pole rotor. The excitation via the rotor is dc excitation, I_r, and it is ac excitation via the stator; given by:

$i_s(t) = I_s \cos(\omega t+\phi)$

Find:

i. The instantaneous torque on the rotor in terms of the coil current and the rotor position.

ii. The average torque, if the rotor rotates at a constant angular velocity of ω (i.e. it is equal to the current angular frequency). Assume that the rotor position at t=0 is equal to zero.

[10Mark/a.1.1, a.15.1,b.2.1, and c.3.1]

c) As shown in Fig. 3, an N-turn electromagnet is used to lift a slab of iron of mass M. The surface roughness of the iron is such that when the iron and the electromagnet are in contact, there is a minimum air gap of g_{min}=0.18 mm in each leg. The electromagnet cross-sectional area A_c=32cm^2. ***Calculate*** the minimum coil current which must be used to lift a slab of mass 95 kg against the force of gravity. Neglect the reluctance of the iron. [10Mark/a.1.1, a.15.1,b.2.1, and c.3.1]

Question Four: (20 Mark) [measures the ILOs of a.1 and c.1]

a) ***Compare*** between mono crystalline and poly crystalline solar panels. [5Mark/ a.1.1]

b) ***Design*** complete off grid solar power station for the following residential loads: [15 Mark/ c.1.1]

Appliance	Qty.	Rated Power [W]	Working Hours [Hrs/day]	Additional Data
Ceiling fan	2	70	7	Single battery capacity is: 12V/100Ahr
Lamps	6	12	7	Single PV panel peak power is: 250 W.
Refrigerator	1	150	9	Depth of Discharge is: 50%.
TV	1	105	4	Autonomy day is: 1.
Water Pump	1	350	2	Average sun hours per day are: 5 hours.
Washing Machine	1	400	1	The input voltage of the inverter is: 24V
The efficiency of both the inverter and the charge controller is: 90%. Assume any missing parameters.				

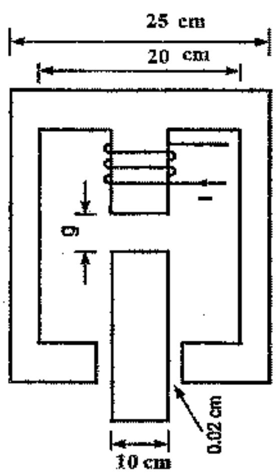

Fig.1 Magnetic circuit of Q_1 (b)

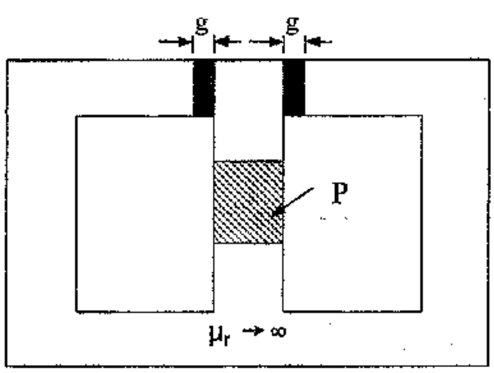

Fig.2 Magnetic circuit of Q_2 (b)

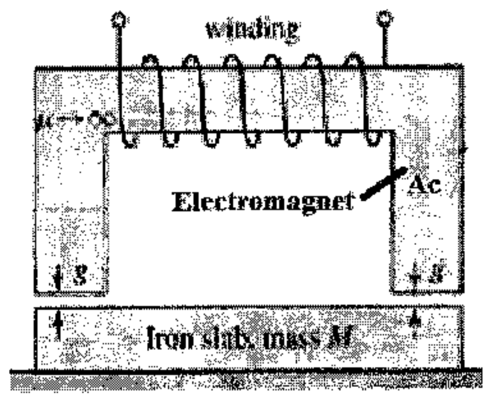

Fig.3 Magnetic circuit of Q_3 (c)

Best Wishes *Committee of corrections and Testers*