Kafrelsheikh University
Faculty of Engineering
Subject: **Electrical Machine 1 (DC)**
Year: Third Electrical Power (R.2007)
Exam Date: 17/1/2018

Final Exam of 1st semester-2017-2018
Department of Electrical Engineering
Course code: EPM3106
Number of pages: 2
Full Mark: 90 Marks
Time allowed: 3 hours

This exam measure ILOs (a1, a15, b2, b5, c3, c16, d5, d7)

Attempt to solve all questions

Q1: (15 Marks)

a) Discuss the effect of the magnitude and direction of force on a current-carrying conductor.

b) The Solenoid consists of 600 turn's rolls along its length by uniform distributed, and has length of 90 cm. If the current path through the coil is 5 A and the coil cross section is 8 cm calculate: flux and flux density in case of the core is made from nonmagnetic material. Flux and flux density in case of the core is made from magnetic material have relative permeability of 200.

===

Q2: (15 Marks)

a) With the help of a neat diagram show power division in DC generator

b) A 4-pole lap wound shunt generator supplies to 50 lamps of 100 W, 200 V each. The field and armature resistance are 50 Ω, and 0.2 Ω respectively. Allowing the brush drop is 1 V, calculate the following: I_a, I_z, emf, P_o

===

Q3: (20 Marks)

a) Explain with the help of net sketches the phenomena of commutation in dc machine, state and discuss the methods adapted for minimizing the sparking at the brushes.

b) A 4-pole wave-wound motor armature has 880 conductors and delivers 120 A. The brushes have been displaced through 3 angular degrees from the geometrical axis. Calculate (a) demagnetising amp-turns/pole (b) cross- magnetising amp-turns/pole (c) the additional field current for neutralizing the demagnetisation of the field winding has 1100 turns/pole.

===

Q4: (15 Marks)

a) Draw the magnetic circuit of a 4 pole D.C. machine.

b) The following is the external characteristic of a shunt generator:

I_L, A	0	4	8	12	16	20
Emf, V	89.5	88.5	87	84.5	82.2	79

Plot internal characteristic if the armature and shunt field resistances are 0.22 and 45 ohms, respectively.

===

Q5:

(15 Marks)

a) Drive an expression for the torque of dc motor.

b) A 4 pole, 32 conductor, lap-wound d.c. shunt generator with terminal voltage of 200 volts delivering 12 amps to the load has $r_a = 2$ and field circuit resistance of 200 ohms. It is driven at 1000 r.p.m. Calculate the flux per pole in the machine. If the machine has to be run as a motor with the same terminal voltage and drawing 5 amps from the mains, maintaining the same magnetic field, find the speed of the machine.

Q6:

(10 Marks)

A 150 kW, 230 V, 500 rpm, dc shunt motor has a square field coil. Find its number of poles and the main dimension and air gap length, assuming B_{av} over the pole arc = 0.85 wb/m^2. ac = 29000 A/m, the ratio of width of pole body to pole pitch is 0.55, pole arc to pole pitch is 0.7, $\eta = 0.91$, $AT_g = 0.55\ AT_a$, field form factor is $K_g = 0.7$

With my best wishes

Dr. Eng./Mohamed I. Abd EL_Wanis

Kafrelsheikh University
Faculty of Engineering
Subject: **Electrical Machine 1 (DC)** Course code: EPM3106 Full Mark: 90 Marks
Year: Third Electrical Power (R.2007) Number of pages: 2 Time allowed: 3 hours
Exam Date: 17/1/2018

Final Exam of 1st semester-2017-2018
Department of Electrical Engineering

Q1

a-

Force on Conductor A Current -Carrying

Figure 1.13(a) shows a conductor lying in a magnetic field of flux density B. The conductor is carrying a current (entering the page). This current sets up a flux in clockwise direction. The external field is in the downward direction. As seen in Fig. 1.13(a), the field of the conductor assists the external field on the right-hand side of the conductor and opposes it on the left-hand side. This produces a force on the conductor towards left. If the direction of the current is reversed Fig. 1.13(b), the flux due to this current assumes counterclockwise direction and the force on the conductor is towards right. In both cases, the force is in a direction perpendicular to both the conductor and the field and is maximum if the conductor is at right angles to the field. The magnitude of this force is

$F = B\,I\,l$ newtons (1.34)

Where B is flux density in tesla, I is the current in amperes and l is the length of conductor in metres.

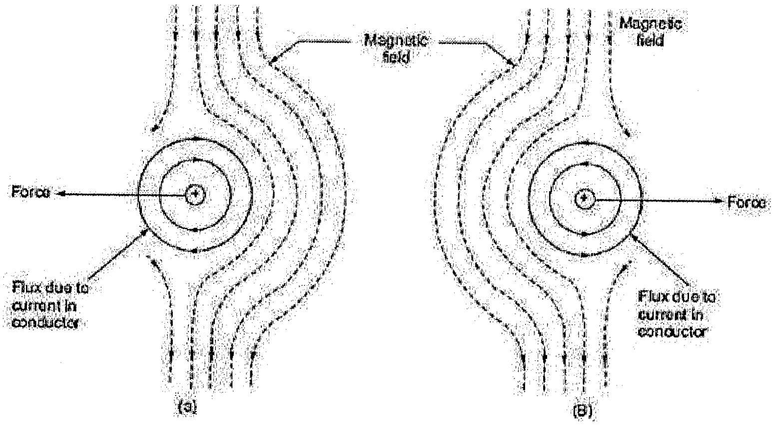


Fig. **Error! No text of specified style in document..**1: Force on a conductor in a magnetic field, (a) current into the page (b) current out of the page

If the conductor is inclined at n angle θ to the magnetic field, the force is

$F = B\,I\,l\,\sin\theta$ N

b-

Solution

In case of nonmagnetic material

$\mu = \mu_o$, $A = \pi r^2 = \pi \times 0.04^2 = 0.005$ m^2

$$B = \frac{N\mu \times I}{L} = \frac{600 \times 4\pi \times 10^{-7} \times 5}{0.9} = 4.17 \times 10^{-3} \text{ T}$$

$\phi = B \times A = 4.17 \times 10^{-3} \times 0.005 = 0.0209$ $m$web

In case of magnetic material

$$B = \frac{N\mu \times I}{L} = \frac{640 \times 4\pi \times 10^{-7} \times 200 \times 5}{0.9} = 0.89 \text{ T}$$

$\phi = B \times A = 0.89 \times 0.005 = 4.47$ $m$web

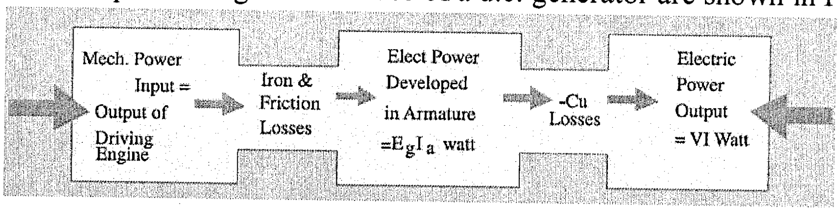
Kafrelsheikh University
Faculty of Engineering
Subject: **Electrical Machine 1 (DC)**
Year: Third Electrical Power (R.2007)
Exam Date: 17/1/2018

Final Exam of 1st semester-2017-2018
Department of Electrical Engineering
Course code: EPM3106
Number of pages: 2
Full Mark: 90 Marks
Time allowed: 3 hours

Q2

a-

Various power stages in the case of a d.c. generator are shown in Figure:



Power flow diagram of dc generator

Following are the three generator efficiencies:

1. Mechanical Efficiency

$$\eta_m = \frac{E_g I_a}{V I_L}$$

2. Electrical Efficiency

$$\eta_e = \frac{V I_L}{E_g I_a}$$

3. Overall or Commercial Efficiency

$$\eta_e = \frac{P_{in}}{V I_L}$$

It is obvious that overall efficiency $\eta_c = \eta_m \cdot \eta_e$. For good generators, its value may be as high as 95%.

6-

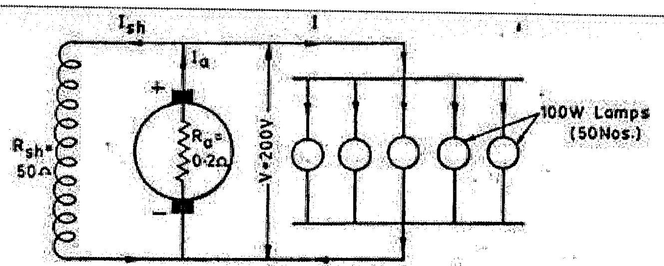


Fig. 1.43

(i) Armature current, I_a :

Load current, $I = \frac{\text{power consumed}}{\text{terminal voltage}} = \frac{P}{V} = \frac{5000}{200} = 25$ A

Shunt field current, $I_{sh} = \frac{V}{R_{sh}} = \frac{200}{50} = 4$ A

∴ Armature current, $I_a = I + I_{sh} = 25 + 4 = 29$ A. **(Ans.)**

(ii) Current per path :

Current per path $= \frac{I_a}{a} = \frac{29}{4}$ [∵ $a = p = 4$, generator being lap wound]

= **7.25 A. (Ans.)**

(iii) Generated e.m.f., E_g :

$$E_g = V + I_a R_a + \text{brush drop} = 200 + 29 \times 0.2 + 2 \times 1 = 207.8 \text{ V}$$

Hence, generated e.m.f. = **207.8 V. (Ans.)**

(iv) Power output of D.C. armature :

Power output of D.C. armature

$$= \frac{E_g I_a}{1000} = \frac{207.8 \times 29}{1000} \text{ kW} = 6.026 \text{ kW. (Ans.)}$$

Q3

a-

"Commutation means the process of current collection by the brush or the changes which take place in a coil during the period of short circuit by a brush."

The above process is illustrated in Fig. 4.11. This diagram shows the commutator segments, the coils connected to the commutator segments, and one of the brushes. The coils to the left of the brush carry current to the brush from left to right. The coils to the right of the brush also carry current to the brush, but from right to lift.

Let us follow coil A as it rotates from left to right and undergoes commutation.

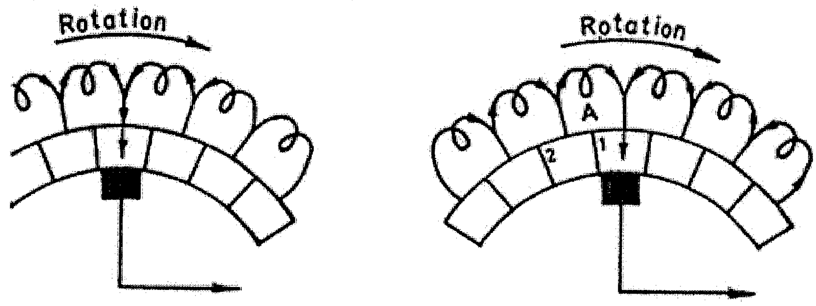


Fig. **Error! No text of specified style in document.**.2: Current in coil, is opposite in direction on either side of the brush.

In Fig. 4.12 (a) current (*I*) flows through coil A from left to right and the magnitude of the current is indicated in Fig. 4.13 (a) as point l.

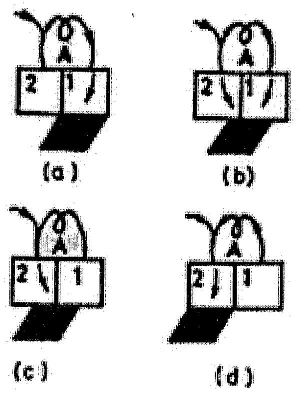


Fig. **Error! No text of specified style in document.**.3: Change in current direction in coil undergoing commutation.

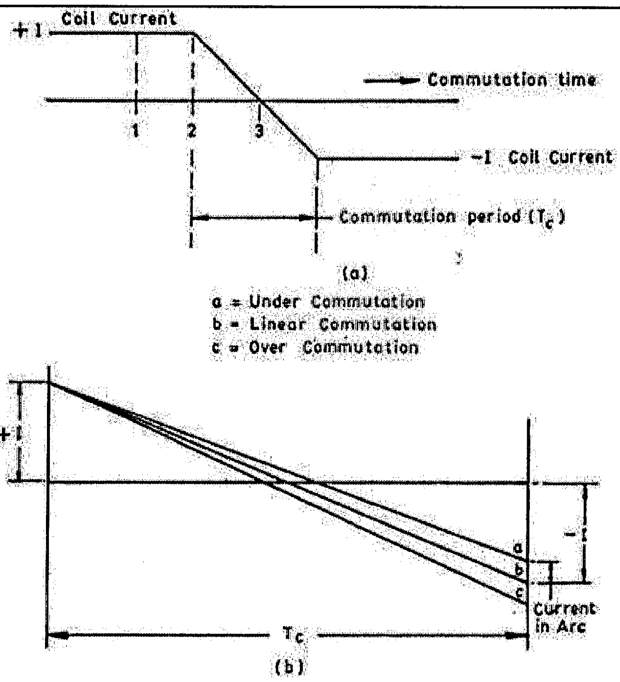


Fig. **Error! No text of specified style in document.**.4: Current during commutation

4.2 Methods of Improving Commutation

Two methods are available for improving commutation i.e. of making the current in the short-circuited coil attain its full value in the reverse direction by the end of the short-circuit period: these are :

1. Resistance commutation.
2. E.m.f. commutation.

6-

Solution. $Z = 880$; $I = 120/2 = 60$ A ; $\theta = 3°$ angular

(*a*) $\therefore \ AT_d = 880 \times 60 \times \frac{3}{360} = 440$ AT

(*b*) $\therefore \ AT_c = 880 \times 60\left(\frac{1}{8} - \frac{3}{360}\right) = 880 \times \frac{7}{60} \times 60 = 6{,}160$

or Total AT/pole $= 440 \times 60/4 = 6600$

Hence, AT_c/pole = Total AT/pole – AT_d/ pole $= 6600 - 440 = 6160$

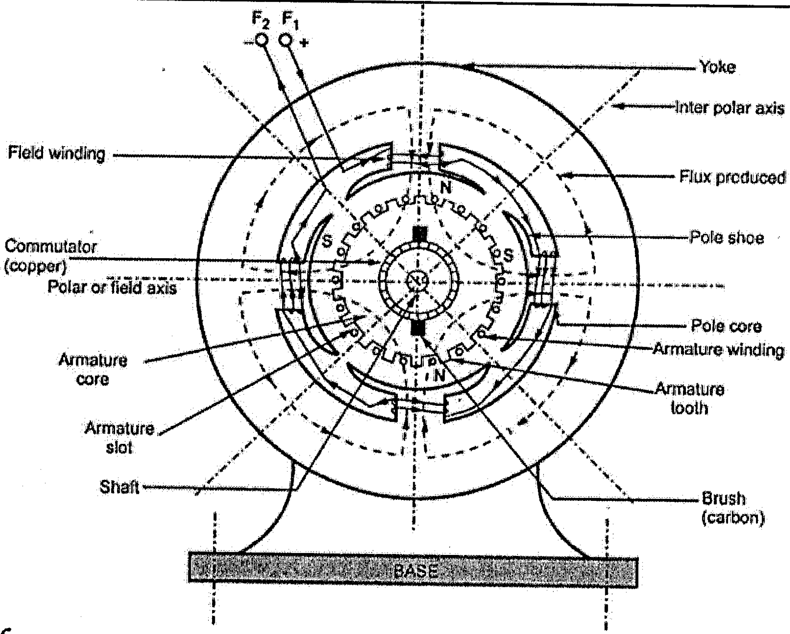
(*c*) Additional field current $= 440/1100 = 0.4$ A.

Q4

a-

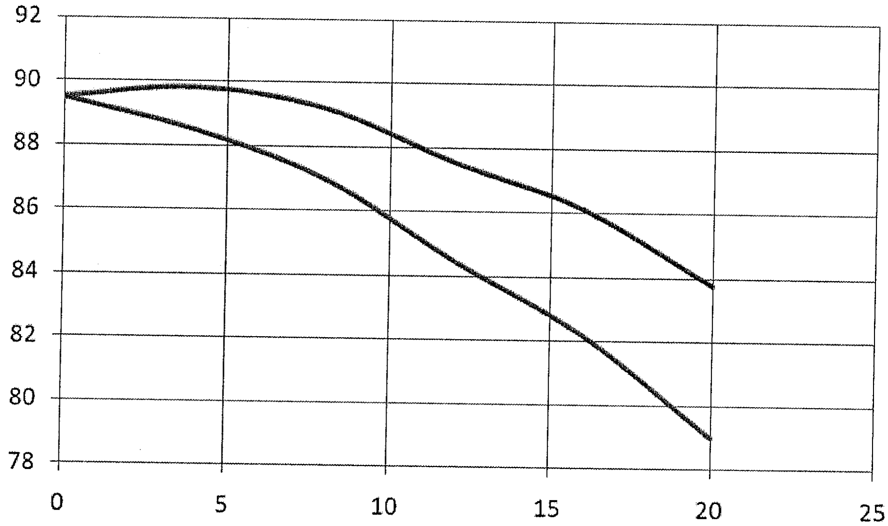
Kafrelsheikh University
Faculty of Engineering
Subject: **Electrical Machine 1 (DC)**
Year: Third Electrical Power (R.2007)
Exam Date: 17/1/2018

Final Exam of 1st semester-2017-2018
Department of Electrical Engineering
Course code: EPM3106
Number of pages: 2
Full Mark: 90 Marks
Time allowed: 3 hours



6-

I_L	V_{ex}	$I_f = V_{ex}/R_f$	$I_a=I_L+I_f$	$V_{in}=V+I_a*R_a$
0	89.5	1.99	1.99	89.94
4	88.5	1.97	5.97	89.81
8	87	1.93	9.93	89.19
12	84.5	1.88	13.88	87.55
16	82.2	1.83	17.83	86.12
20	79	1.76	21.76	83.79

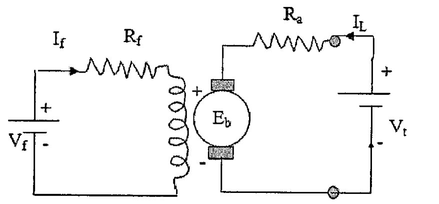


Q5
a-

Kafrelsheikh University
Faculty of Engineering
Subject: **Electrical Machine 1 (DC)**
Year: Third Electrical Power (R.2007)
Exam Date: 17/1/2018

Final Exam of 1st semester-2017-2018
Department of Electrical Engineering
Course code: EPM3106 Full Mark: 90 Marks
Number of pages: 2 Time allowed: 3 hours

1- Separately Excited DC Motor



Field : $V_f = R_f I_f$

Armature: $E_a = V_t - I_a R_a$

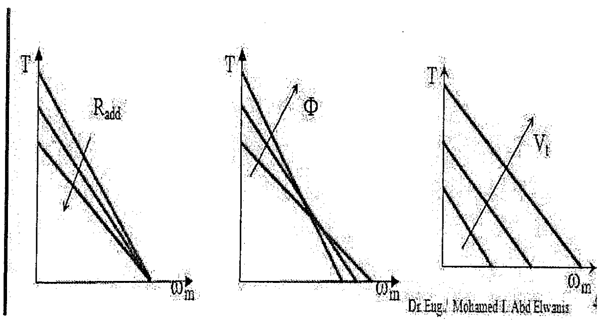
$E_a = K\,\Phi\,\omega_m$

$T = k\,\Phi\,I_a$

$$T = \frac{K\Phi}{R_a}(V_t - K\Phi\omega_m)$$

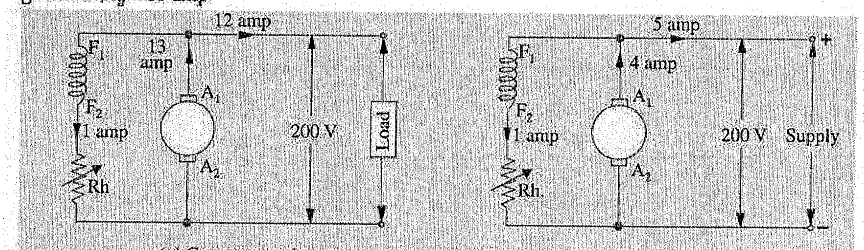
$P_d = E_a I_a$ $P_{in} = V_t I_L$

$Td = Pd \times 60/(2\pi n)$



6-

Solution. Current distributions during two actions are indicated in Fig. 29.9 (*a*) and (*b*). As a generator, $I_a = 13$ amp



(*a*) Generator-action (*b*) Motor-action

Fig. 29.9

$$E_g = 200 + 13 \times 2 = 226 \text{ V}$$

$$\phi \frac{ZN}{60} \times \frac{P}{a} = 226$$

For a Lap-wound armature,

$$P = a$$

$$\therefore \quad \phi = \frac{226 \times 60}{1000 \times 32} = 0.42375 \text{ wb}$$

As a motor,

$$I_a = 4 \text{ amp}$$

$$E_b = 200 - 4 \times 2 = 192 \text{ V}$$

$$= \phi ZN/60$$

$$\text{Giving } N = \frac{60 \times 192}{0.42375 \times 32}$$

$$= 850 \text{ r.p.m.}$$