University of Saskatchewan
Department of Electrical Engineering
EE 313.3 Electrical machines I
Midterm Examination

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1. Mark the following statements true (T) or false (F).

(a) The generated voltage in a dc generator is directly proportional to the net flux per pole.

(b) The number of parallel paths in a dc generator with wave winding is equal to the number of poles in the machine.

(c) In a dc generator, the commutator acts as a rectifier, so that the output at the armature winding terminals is direct current.

(d) The net effect of armature reaction can be considered as a reduction in the field current.

(e) To counteract the effect of armature reaction, the brushes of a dc machine should be placed in the geometric neutral axis of the machine.

(f) The compensating winding of a large dc machine is connected in series with the field circuit of the machine.

(g) A linear change of current with time in the commutated coil of a dc machine, known as linear commutation, ensures sparkless commutation.

(h) Reactance voltage prevents current reversal in the commutated coil of a dc machine to be completed at the end of the commutation period.

(i) In voltage commutation, a rotational voltage is generated in the commutated coil of a dc machine to balance the reactance voltage of the coil.

(j) The speed of a dc motor is directly proportional to the air-gap flux per pole of the machine.

(k) For both shunt and series motor, the electromagnetic torque is directly proportional to the armature current.

(l) For a given electromagnetic torque, armature resistance and field current, the speed of a dc motor varies linearly with the armature voltage.

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2. The open-circuit characteristic data of a dc shunt generator at 1200 rpm are given below:

Field current (A)	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	6.0
Term. voltage (V)	67	100	134	160	180	200	210	220	230	242

The generator has armature circuit resistance of 0.07 Ω and field circuit resistance of 36 Ω. The generator is operated at 1000 rpm.
(a) Find the generated voltage at no load.
(b) Find the generated voltage and the terminal voltage when the armature current is 200 A. Neglect armature reaction.

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3. A dc series motor is connected to a 600-V dc supply and draws a line current of 330 A at rated output. The speed of the motor at the rated output is 900 rpm. The total resistance of the armature and the series field winding is 0.12 ohm. Determine both speed and electromagnetic torque when the load changes so that the machine draws a line current of 207 A. Neglect saturation and armature reaction.

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4. A 240 V, 10 kW dc shunt motor draws an armature current of 20 A while producing a counter emf of 230 V at 1000 rpm. Determine the output of the motor, if the rotational, field and armature copper losses are 1 kW, 800 W and 200 W respectively.

THE END

$\frac{67}{1200} = \frac{x}{1000}$

DC MACHINES

EMF, and Electromotive Force: $e=\bar{v}\times\bar{B}l$, $f=\bar{i}\times\bar{B}l$, v = velocity, i = current, B = field, l = length, e = EMF, f = force

Lenz's Law: $e=-\frac{\delta\lambda}{\delta t}=-\frac{\delta(N\phi)}{\delta t}$, λ = flux linkage passed through, N = #turns, ϕ = flux

Avg. Generated EMF: $e_s=\frac{P\phi nZ}{60a}$, e_s = generated emf, ϕ = flux per pole, P = # poles, Z = # conductors, a = parallel paths, n = (RPM).

$$\theta_{ed}=\frac{P}{2}\theta_{mech}$$

	Generators	DC Motor: Shunt	DC Motor: Series
Terminal Voltage	$V_t = E_a - I_aR_a$		
Back EMF		$E_a = V_t - I_aR_a$	$E_a = V_t - I_aR_a - I_aR_f$
Back EMF/Speed	$E_a = K_a\phi_d\omega_m$	$E_a = K_a\phi_d\omega_m$	$E_a = K_a\phi_d\omega_m$
Electromagenetic Power		$P_e = E_aI_a$	$P_e = E_aI_a$
Input Power		$V_tI_L = V_tI_a + V_tI_f$	$V_tI_L = E_aI_a + I_a^2R_a + I_a^2R_f$
Output Power	$P_{out} = V_tI_L$	$P_{out} = P_e$ - mech losses	$P_{out} = P_e$ - mech losses
Electromagnetic Torque/Power		$T_e\omega_m = P_e = E_aI_a$	$T_e\omega_m = P_e = E_aI_a$
Electromagnetic Torque/Current		$T_e = K_a\phi_d I_a$	$T_e = K_a\phi_d I_a$
Neglecting Saturation and armature reaction		$\phi_d = K_1I_f$ $E_a = K_2I_f\omega_m$ $T_e = K_5I_fI_a$	$\phi_d = K_3I_a$ $E_a = K_4I_a\omega_m$ $T_e = K_6I_a^2$

V_t = terminal voltage, E_a = generated emf, I_a = Armature current, I_f = field current, I_L = Load/Line current, Ra = armature resistance plus effecitve brush-commutator contact resistance , R_f = field resistance, ω_m = angular speed (radians) = $2\pi n/60$ where n = speed (RPM), P_e = Electromagnetic Power

Speed Regulation: $SR=\frac{N_{NL}-N_{FL}}{N_{FL}}$, N = speed

Voltage Regulation: $VR=\frac{V_{tNL}-V_{trated}}{V_{trated}}$, Vt = terminal voltage