University of KwaZulu-Natal
Electrical, Electronic and Computer Engineering

Main Exam: 06 June 2026, 09:00 – 11:00

DURATION:	**2 HOURS**	**TOTAL MARKS: 75**
Examiners:	Mr M. Brown	(Internal)

INSTRUCTIONS:

- Only non-programmable calculators may be used.
- This is closed book exam so no additional information may be taken into the exam room.
- Answer all questions, show all working and include all necessary comments.
- Marks will be deducted where no or incorrect units are used, where figures and plots are labelled incorrectly and where writing is illegible.

Question 1 [10]
A chemical factory in Durban is automating a continuous manufacturing process that operates at low speeds and requires precise flow control. The environment is classified as hazardous due to the constant release of hydrogen gas. Recommend a specific motor-drive combination with technical reasoning. Additionally, provide a block diagram of the electric drive system.

Question 2 [10]
A DC machine is the prime mover of a 200 kg electric go-kart. At 20 km/hour the go-kart needs 5 kW of traction power while the motor speed is 4000 rpm. If the motor is capable of three times as much torque as it is presently providing what is the maximum gradient the vehicle can climb without reducing its speed if the driver is 100 kg?

Question 3 [10]
An electric go-kart is designed to go forwards only. However, the go-karts are running out of battery power too early as a result of all the braking into the turns slowing the drivers down and then needing to accelerate out of the turn. If the go-karts run on DC machines select an appropriate chopper drive, explain its operation and the quadrants it operates in.

Question 4 [10]
The speed of a 10 hp, 220 V, 1200 rpm, separately excited DC motor is controlled by a single-phase full converter. The rated armature current is 40A. The armature resistance is $R_a = 0.25\ \Omega$ and the armature inductance is $L_a = 10\,mH$. The AC supply voltage is 265 V. The motor voltage constant is $K_a = 0.18\,V/rpm$. Assume the motor current is continuous and ripple free. For a Firing angle $\alpha = 30°$ and rated motor current, determine:

a) The speed of the motor. [4]
b) The motor torque. [3]
c) The power to the motor. [3]

Question 5 [10]
A voltage source inverter supplies a 4-pole, three-phase induction motor rated at 50 Hz and 220 V.

a) Determine the approximate output voltage required from the inverter for a motor speed of 800 rpm and 1200 rpm. [6]
b) If the full-load slip is 4%, determine the rotor speed in rpm, and the frequency of the rotor's EMF. [4]

Question 6 [15]

A single-phase residential load of a 240 V, 5 kW is supplied through a single-phase, 25 kVA distribution transformer with a leakage reactance of 4%. The input current harmonic components are given in Table 1 as a percentage of the fundamental frequency current component. The displacement power factor is approximately 1.

a) Calculate the short-circuit capacity of the system at the 240 V load, assuming the impedance of the rest of the system other than distribution transformer to be negligible. [5]

b) Are the harmonics and THD within the limits specified in Table 2? [10]

Table 1: Current Harmonics Ratios

h	3	5	7	9	11	13	15	17	19	21	23
$\left(\frac{I_h}{I_1}\right)\%$	34.0	5.3	1.8	1.8	1.6	1.2	0.9	0.8	0.8	0.4	0.4

Table 2: Harmonics Standards

	Odd Harmonic Order h (%)					*Total Harmonic Distortion (%)*
I_{SC}/I_1	$h < 11$	$11 \leq h < 17$	$17 \leq h < 23$	$23 \leq h < 35$	$35 \leq h$	
<20	4.0	2.0	1.5	0.6	0.3	5.0
20–50	7.0	3.5	2.5	1.0	0.5	8.0
50–100	10.0	4.5	4.0	1.5	0.7	12.0
100–1000	12.0	5.5	5.0	2.0	1.0	15.0
>1000	15.0	7.0	6.0	2.5	1.4	20.0

Question 7 [10]

a) Discuss displacement and distortion power factor. Your discussion should include figures. [5]

b) Discuss THD and TDD. Explain why TDD is a better indication for system design and compliance. [5]

END OF PAPER

Formula Sheet

Average

$$V_o = \frac{1}{T_s}\int_0^{T_s} v(t)\, dt$$

Root mean Square

$$V_{rms} = \sqrt{\frac{1}{T}\int_0^{T} v^2(t)\, dt}$$

$If\, v = v_1 + v_2 + v_3 + \cdots$

$then$

$$V_{rms} = \sqrt{V^1_{1\,rms} + V^2_{2\,rms} + V^2_{3\,rms} + \cdots}$$

Harmonics

$$THD = \frac{\sqrt{\sum_{n=2}^{\infty} I_n^2}}{I_1}$$

Transformer (Ideal)

$$\frac{V_p}{N_p} = \frac{V_s}{N_s}$$

Trig Identities

$$sin(\alpha \pm \beta) = sin\ \alpha\ cos\ \beta \pm cos\ \alpha\ sin\ \beta$$

$$cos(\alpha \pm \beta) = cos\ \alpha\ cos\ \beta \mp sin\alpha\ \ sin\ \beta$$

$$tan(\alpha \pm \beta) = \frac{tan\ \alpha \pm tan\ \beta}{tan\ \alpha\ tan\ \beta}$$

$$sin\ (2\theta) = 2\ sin\ \theta\ cos\ \theta$$

$$cos\ (2\theta) = cos^2\theta - sin^2\theta$$

$$cos\ (2\theta) = 2cos^2\theta - 1$$

$$cos\ (2\theta) = 1 - 2\ sin^2\theta$$

$$tan(2\theta) = \frac{2\ tan\ \theta}{1 - tan^2\ \theta}$$