University of KwaZulu-Natal

School of Electrical, Electronic & Computer Engineering

Examinations: November 2016

DURATION: 2 HOURS **TOTAL MARKS: 60**

Examiners: Mr. M. Asiyo (Internal)
Dr F. Ghayoor (Internal)
Dr. R. Pillay Carpanen (Internal)
Dr C. Venugopal (Moderator)

Instructions:
1. Your answers to Sections A, B and C must be submitted in **separate examination books**
2. Answer **ALL** questions.
3. Programmable calculators may be used provided their **memories** have been **cleared**
4. Answers may be written in a **dark** pencil

Data: $\mu_0 = 4\pi \times 10^{-7}\ H/m$ $\varepsilon_0 = \frac{10^{-9}}{36\pi}\ F/m$ $c = 3 \times 10^{8}\ m/s$

Section A: Electronic Design: [20 Marks]

Ensure you use a separate answer book for this section.

Question A1

Design a digital electronic system that functions as an **up counting** Stopwatch. The system should have a three 7-segment display one for minutes, one for seconds and the last for tenths of a second. It should also have two buttons: (1) start/stop and (2) to reset it to 0.

a) Provide a detailed functional block diagram for your design solution to the above specification. **[5]**

b) Use a 555 timer in astable mode to provide the clock signal for the stopwatch. The duty cycle can be any arbitrary value but the frequency must be 10Hz. Draw a schematic of the timer (pin positions are not important), give a detailed explanation of its operation in this mode and show calculations for component values. **[10]**

c) Give a definition of fan-in for a logic family. **[2]**

d) Table 1 below shows current characteristics of a certain SN74SL series TTL logic family. Use the data to show calculations for determining the fan-out of the TTL logic gate. **[3]**

Table 1: SN74SL series TTL logic family current characteristics

Parameters	Current Value
Output current when the gate is HIGH (I_{OH})	-0.4 mA
Input current when the gate is HIGH (I_{IH})	40 μA
Output current when the gate is LOW (I_{OL})	8 mA
Input current when the gate is LOW (I_{IL})	-1.6 mA

END OF ELECTRONIC DESIGN SECTION

Section B: Instrumentation & Measurements [20 marks]

Ensure you use a separate answer book for this section. Answer ALL questions.

Question B1 [4 marks]

This question consists of multiple choice questions worth 1 mark each. Simply write down the capital letter of the statement that matches best.

a) The given bridge in Figure B1 is in null condition. The value of capacitor C is equal to

A. 0.76 pF
B. 190.5 pF
C. 76 pF
D. 0.1905 pF

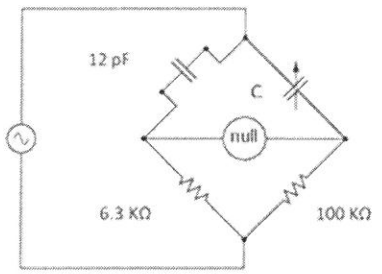

Figure B1

a) Sensitivity of a measurement instrument is ...

A. The ratio of the response of the instrument to the change of time.
B. The ratio of the response of the instrument to the change of measured variable.
C. The ratio of the change of measured variable to the response of the instrument.
D. The ratio of the change of measured variable to the change of time.

b) The meaning of the term *precision* is

A. A measure of the reproducibility of the measurement.
B. The ratio of the response of the instrument to a change of the measured variable.
C. Closeness of an instrument reading to the true value of the variable being measured.
D. The smallest change in the measured value to which the instrument will respond.

c) Which of the following can be measured by using an oscilloscope?

1. Voltage of a 30 GHz signal
2. Frequency of a 30 GHz signal
3. DC voltage component of a signal
4. Rise time of a low frequency pulse signal
5. Phase of a 30 GHz signal

A. 1,2 and 5
B. All of them
C. 1, 2, 3 and 4
D. 3 and 4

Question B2 [12 marks]

Three-resistors are connected to a PMMC instrument to make an ammeter as shown in Figure B2. Calculate the resistance values to achieve the required current measurement ranges. The meter has R_m = 2 kΩ and full-scale deflection current of 50μA.

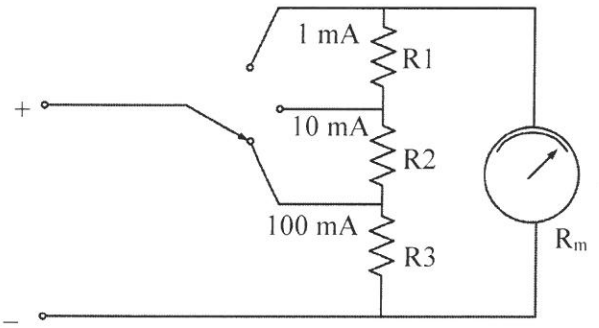

Figure B2

Question B3 [4 marks]

The rectangular voltage signal shown in Figure B3 is applied to a digital voltmeter [the y-axis shows voltage in volts and the x-axis shows time in milliseconds]. What is the true rms voltage of the signal? (Show by calculation)

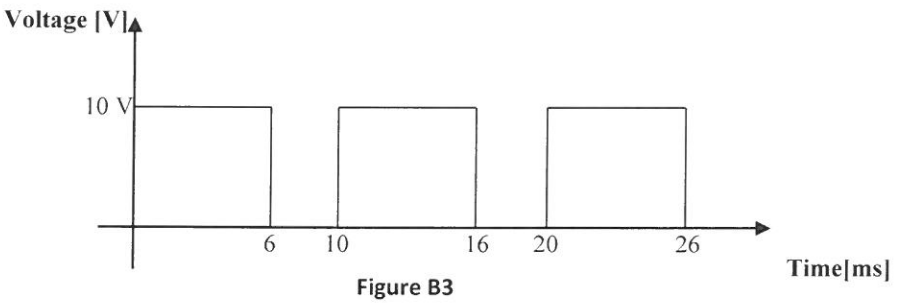

Figure B3

END OF INSTRUMENTATION & MEASUREMENTS SECTION

Section C: Actuator Design [20 Marks]

Ensure you use a separate answer book for this section.

Question C1

Consider the DC electromagnetic actuator shown in the Fig. C1 which is constructed from Armco Iron. The coil of the actuator comprises 300 turns and is supplied from a DC voltage source. All dimensions shown are in millimeters.

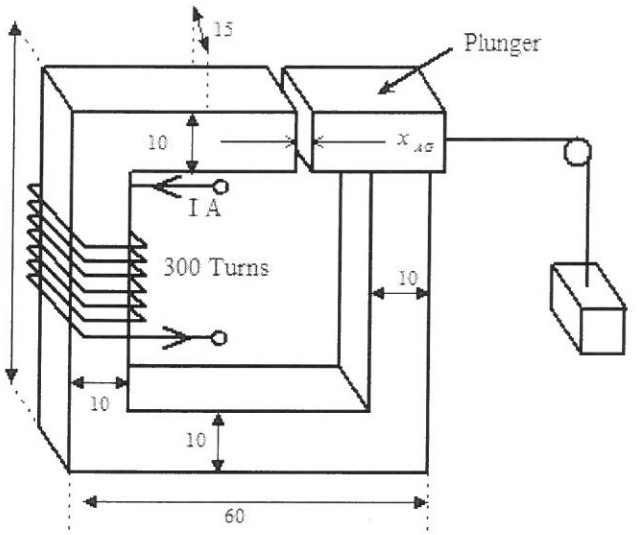

Figure C1

It is desired to operate this actuator at a flux density of 1.35 T when the length of the air gap x_{AG} is 1.0 mm.

(a) Calculate the total magnetomotive force (mmf) required at the input to this magnetic circuit (i.e. the required mmf of the coil) in order to achieve the required flux density at an air gap of 1.0 mm. Neglect fringing in the air gap but **do not neglect the reluctance of the magnetic steel**. [4]

(b) From your solution to part (a), calculate the reluctance of the entire magnetic circuit and current I in the coil under these operating conditions. [3]

(c) Given that when an object is connected to the plunger as shown in Fig. C1, the plunger moves by a horizontal distance of 0.1 mm and thus increasing the length of the air-gap to 1.1mm. Re-calculate the reluctance of the entire magnetic circuit for the condition when the length of the air gap x_{AG} has been increased to 1.1 mm for the input value of mmf calculated in part (a). Neglect fringing in the air gap but do not neglect the reluctance of the magnetic steel. Work to an accuracy of less or equal to five percent. [8]

(d) Estimate the force generated by this actuator for the condition when the length of air gap x_{AG} is 1.0 mm for the input value of mmf calculated in part (a). Hence, determine the mass of the object in Kg, that is connected to the plunger. [g = 9.807 ms^{-2}] [5]