UNIVERSITY OF JOHANNESBURG

PROGRAM	: *BACHELOR OF ENGINEERING TECHNOLOGY*: ELECTRICAL
SUBJECT	: **Sensors and Devices – Supp Exam**
CODE	: **SENELA2**
DATE	: July 2019
DURATION	: 180 minutes (3 hours)
FULL MARKS	: 100

ASSESSOR	: Mr. J Venter
MODERATOR	: Dr JW Lambrechts
NUMBER OF PAGES	: 8 (including cover page)
INSTRUCTIONS	: ONLY ONE POCKET CALCULATOR PER CANDIDATE MAY BE USED. FILL IN ANSWERS ON THE PAPER

QUESTION 1 [19]

1.1 Sketch a graph of a sine wave with excess noise. (3)

1.2 Describe using one graph the difference between each signal (DC signal, AC signal and Mixed signal) (5)

1.3 Why do we ideally need a signal that is larger than the noise floor of the system in any measurement device? What is the effect if the signal is smaller than the system noise (2)

1.4 Derive the empirical relationship of the following linear dataset and sketch the graph. The characterization is for a distance measuring system. (9)

Distance(cm)	Time (µs)
40	10
49	20
60	31
69	40

QUESTION 2 [23] – Temperature sensing

2.1 Two common temperature sensors commonly used in industry are the PT100 and the PT1000. What is the difference between these two? Specifically state the resistance at a specific temperature. (4)

2.2 What is the difference between conduction, convection and radiation? (3)

2.3 What is the increase in resistance of a gold-based RTD detector with the following specifications? α=0.0040 Ω/Ω/^{0}C, ΔT= 30 ^{0}C, R_0 = 500 Ω. (3)

$$R_T = R_0(1 + \alpha\Delta T)$$

2.4 A Thermocouple contains a semi-conductor to perform temperature sensing. What is a semiconductor? (3)

2.5 Using the following equation, sketch the graph of diode resistance (R in Ω) versus temperature (T in Kelvin) for the following combinations of current flow and biasing voltage. The application is a diode temperature sensor. (10)

Use the following values ($I_S = 10^{-12}$A, k = 1.3806 × 10^{-23} J/K, q = 1.602 × 10^{-19} C).

$$I_D = I_S e^{qV_D/kT}$$

V_D (V)	I_D (mA)
0.50	0.1
0.50	0.5
0.50	1
0.50	2
0.50	3

QUESTION 3 [18] – Light sensing

3.1 Describe the principle of light sensing. Make specific mention under which conditions electron flow will occur and include a brief discussion on material bandgap. (5)

3.2 Describe the conversion process of a bolometer. (3)

3.3 Under which circumstances for light sensing would one make use of a Darlington pair? By using the Beta of the transistors (β) provide the model current equation for a Darlington transistor pair. (4)

3.4 List 6 electrical characteristics of a light sensor operating in photoconduction mode. (6)

QUESTION 4 [10] – Sound sensing

4.1 Describe the piezoelectric effect from a scientific point of view? (5)

4.2 For a Doppler flow meter calculate the angle α at which the transmitter of the flow meter is orientated with respect to the flow of water in a pipe with the following specifications. (f_{rx} = 100 Hz, f_{tx} = 90 Hz, c = 1500 m/s, v = 400 m/s). (5)

$$v = \frac{(f_{rx} - f_{tx})c}{2f_{tx}\cos\varphi}$$

QUESTION 5 [11] – Magnetic sensing

5.1 Describe Lenz's Law (3)

5.2 Two uses of induction is Near-Field Communication (NFC) and induction stoves. Describe the basic operation of each of these applications. (8)

QUESTION 6 [19] – Devices

6.1 Why does a Metal Oxide Varistor only conduct with high voltages and not at small voltages? (5)

6.2 Describe two major common practice errors when a fuse blows? What dangers do these practices hold in future circuit operation? (6)

6.3 Sketch the structure of a SCR using circuit symbols. (2)

6.4 What is the difference between a TRIAC and a SCR with regards to gate triggering and operation? Specifically discuss the conditions to switch the device ON and to switch it OFF. (6)