The Open University of Sri Lanka
Faculty of Natural Sciences
B.Sc/ B. Ed Degree Programme

Department	: Physics
Level	: 05
Name of the Examination:	Final Examination
Course Code and Title	:PHU5303/PYU3164/PYE5164- Data Acquisition and Signal Processing
Academic Year	: 2019/2020
Date	: 30th December, 2019
Time	: 1.30 pm- 3.30 pm
Duration	: 2 hours

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **06**questions in **04** pages.
3. Answer any **04**questions only. All questions carry equal marks.
4. Answer for each question should commence from a new page.
5. Draw fully labelled diagrams where necessary
5. Relevant log tables are provided where necessary.
6. Having any unauthorized documents/ mobile phones in your possession is a punishable offense
7. Use blue or black ink to answer the questions.
8. Circle the number of the questions you answered in the front cover of your answer script.
9. Clearly state your index number in your answer script

Question Number	1	2	3	4	5	6

The Open University of Sri Lanka
B.Sc. Degree Programme- Level 05
Final Examination 2019/2020
PHU5303/PYU3164/PYE5164- Data Acquisition and Signal Processing
Duration: Two (2) Hours
Date: 30.12.2019 **Time: 1.00 p.m. – 3.00 p.m.**

ANSWER ANY FOUR (04) QUESTIONS ONLY.

1. (a) Write down four (04) radiation detectors.

Read the passage to answer the questions given below

A scintillation counter is an instrument for detecting and measuring ionizing radiation by using the excitation effect of incident high energy radiation on a scintillating material, and detecting the resultant light pulses. The excitation effect is exhibited by many organic and inorganic materials.

It consists of a scintillator which generates photons in response to incident radiation and a sensitive photodetector, usually a photomultiplier tube (PMT).

Scintillation counters are widely used in radiation protection, assay of radioactive materials and physics research because they can be made inexpensively yet with good quantum efficiency and can measure both the intensity and the energy of incident radiation. Figure 01 shows a Schematic diagram of a scintillation counter.

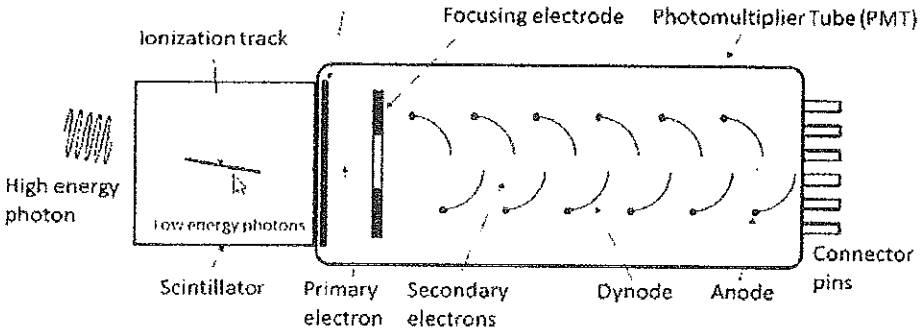

Figure 1

(b) i. Write down the main purpose of using a scintillation counter.

ii Give some examples for high energy radiation.

(c) i. What do you mean by excitation effect?

ii Explain, how the excitation occur in organic and inorganic materials

iii Name one organic and inorganic material used in scintillation counters.

(d) i Write down the main three (03) parts of a scintillation counter and explain their functions.

ii Describe, why scintillation counters are widely used in nuclear research.

(e) Explain with proper diagram how to detect the position and the speed of a high energy particle using a scintillation counter.

2. (a) i. Write down the purpose of using external controlling devices in data acquisition system.

ii. Figure 2 (a) and (b) show two relay devices used in electronic circuits. Explain the working principle of a relay and identify the differences between the given two devices.

Figure 2 (a)

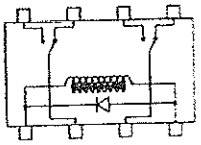

Figure 2 (b)

iii You are given a Light Dependent Resistor (LDR), a Transistor, one of the above mentioned relay devices and some resistors. Draw a circuit of a light activated switch that uses the above components and briefly discuss the operation of your circuit.

(b) Derive an expression for the voltage gain of an inverting amplifier with proper circuit diagram

(c) i What do you mean by the term "differential amplifier"?

ii Figure 3 shows the circuit diagram of a differential amplifier. Name the terminals A and B in the operational Amplifier.

iii Find the potentials at A and B.

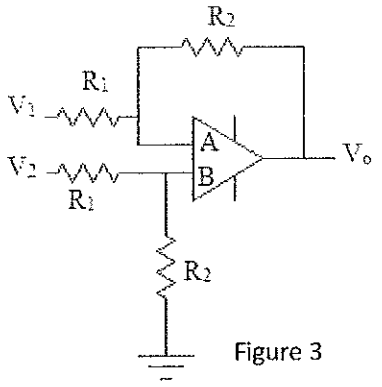

Figure 3

(d) Hence show that the output voltage of the differential amplifier is given by $V_o = \frac{R_2}{R_1}(V_2 - V_1)$. State any assumptions you make.

(e) For the given differential amplifier circuit $R_2 = 5\ k\Omega$, $V_1 = 2$ V, $V_2 = -1$ V and supply voltage $\pm$ 9 V, calculate the minimum and maximum values for R_1.

3. (a) Briefly discuss why the filter circuits are widely used in signal processing

(b) Using a capacitor and a resistor draw a low pass filter circuit and a high pass filter circuits and plot their response curves.

(c) A frequency generator produces signals of frequencies less than 4 kHz. It has been found that 10 kHz noise is also produced due to heat generated in the circuit and mixed with the signal. Design simple RC high pass filter to remove this noise. Find a suitable value for capacitor when the resistor is 1 kΩ.

(d) A high pass RL filter is shown in figure 4. Combining the above mentioned RC filter circuit construct a band pass filter. Give reason for any modification in individual circuits during the combination.

(e) Briefly discuss how the following circuits are used in signal processing

i Comparators
ii Schmidt Triggers
iii Discriminators

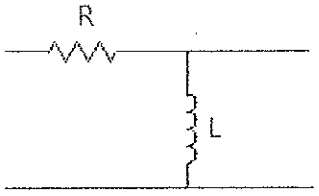

Figure 4

4. (a) A periodic signal *f(t)* with period T_0 can be written using Fourier analysis as

$$f(t) = \frac{A_0}{2} + \sum_{n=1}^{\infty} [A_n cos 2\pi n f_0 t + B_n sin 2\pi n f_0 t]$$

Where, $f_0 = 1/T_0$. Write down expressions for the coefficients A_0, A_n and B_n

(b) Show that the *f(t)* can also be written as

$$f(t) = \alpha_0 + \sum_{n=1}^{\infty} \alpha_n sin(2\pi n f_0 t + \varphi_n)$$

(c) After Fourier analysis of a signal, the coefficients A_0, A_n and B_n were found to be 1, 0 and $\frac{1-cos n\pi}{n\pi}$ respectively. Write down five terms of the Fourier series given by (a)

(d) Find α_0, α_n and φ_n of the Fourier series given in (b) using the values of A_0, A_n and B_n and write few terms accordingly.

(e) Draw the power spectrum of this signal.

5. (a) Define the following terms referred to analogue to digital conversion of a signal.

i. Range
ii. Resolution
iii. Quantization error and
iv. Sampling error

(b) Voltage of an analogue signal varies from 0 – 5 V at a constant rate of 0.5 V per second.

i Find the range and resolution of 8 bit ADC used to digitize this signal.

ii If the conversion time of the ADC is 1 s, determine the corresponding binary outputs of the ADC when the signal change from 0 – 5 V.

iii What is the quantization and sampling error of this ADC?

(c) i. State the sampling theorem.

ii. If humans can hear range of frequencies from 4 Hz to 20 kHz, calculate the sampling time that must be used to digitize high quality music.

(d) Name five types of ADCs and arrange them in ascending order of conversion time.

(e) i. Draw a labeled diagram of a single slope ADC with 8 bit counter.

ii. If the rate of the counter is 10 kHz, what will be the conversion time?

6. (a) Draw a labeled block diagram of typical microprocessor and briefly explain the purpose of having each component.

(b) A microprocessor consists of a 4 bit data bus and a 10 bit address bus

i Calculate the amount of memory addressable by this microprocessor

ii How would you construct external memory for the above processor using 2114 (256 × 4) SRAM chip given in figure 5?

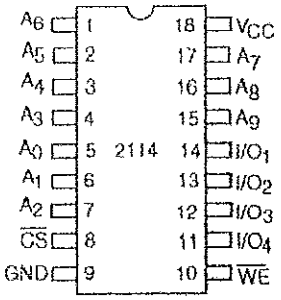

Figure5

(c) What is the task of following registers in a typical microprocessor?

i. Programme counter (PC) ii. A and B Accumulators iii. Flag register

(d) Following is a simple assembly language programme written for a microprocessor.

Assembly language	Machine language
MOVE A, 00	01 00
MOVE B, O3	02 03
ADD A, B	07
DEC B	04
CMP B, 00	06 00
JG 14	09 14
NOP	0B

i Write down the meaning of each mnemonic in this programme.

ii. How do you store this programme in external memory staring from the address 10h?

(e) When you run the programme stored in the memory, draw a table to illustrate the change of the content of PC, A, B and the Flag register.

END