



**UNIVERSITY OF MINES AND TECHNOLOGY, TARKWA**  
**FIRST SEMESTER EXAMINATIONS, NOV. – DEC. 2018**

**COURSE NO:** MN, PE, MC, EL 467  
**COURSE NAME:** INSTRUMENTATION AND CONTROL  
**CLASS:** MN, PE, MC, EL IV **TIME: 3 HOURS**

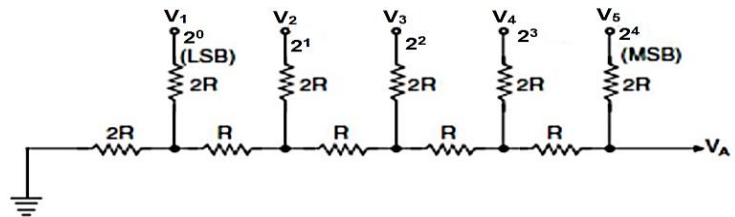
Name: \_\_\_\_\_ Index Number: \_\_\_\_\_

**PLS, ANSWER ALL QUESTIONS FROM ALL SECTIONS**

**Section 1: MULTIPLE CHOICE [15 Marks]**

**Choose the most appropriate letter from the options given.**

1. The analogue output  $V_A$  obtained from the binary ladder DAC network having a digital word of **11001** is:

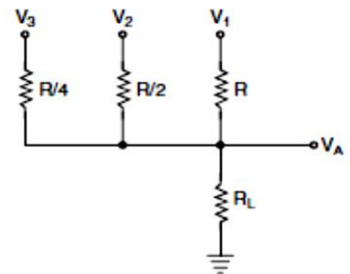


- a. 9.677 V                      b. 7.125 V                      c. 9.375 V                      d. 7.355 V

2. Which of the following types of errors can be traced to a defect in the measuring instrument?  
 a. Systematic                      b. Random                      c. Gross                      d. instrumentation

3. All these are units of mass except:  
 a. lb                      b. g                      c. cd                      d. kg

4. Using the resistive divider network shown, convert the digital word **11001** into an analogue voltage.  
 a. 9.677 V                      b. 7.125 V                      c. 9.375 V                      d. 7.355 V



5. Systematic errors lead to a lack of:  
 a. precision in the measurement.                      c. significant digits in the measurement.  
 b. accuracy in the measurement.                      d. gradation of the measuring instrument.

6. C What quantity is measured using the following unit? cubit<sup>2</sup>  
 a. length                      b. volume                      c. area                      d. mass

7. Just after calibration, reliability is equal to:  
 a. 100                      b. 1                      c. 0                      d. infinity

8. Which of these is an example of a closed loop system  
 a. simple to design                      c. more accurate than counterpart system  
 b. unaffected by external noise                      d. easy to maintain

9. Which of these are examples of a closed loop system.  
 a. door lock system                      b. thermostat heater                      c. voltage stabilizer                      d. electric hand drier

10. The resolution of a 10-bit digital word, with  $\pm 15$  V analogue voltage range is:  
a. 4.88 mV                      b. 29.33 mV                      c. 4.88 V                      d. 29.33 kV

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*Preamble for Questions 11 – 15:* In a differential amplifier, the output voltage is given as:  $V_{out} = \frac{R_f}{R_{in}}(V_2 - V_1)$  where  $V_2 = 150 \pm 3$  V,  $V_1 = 100 \pm 3.5$  V,  $R_f = 4.70 \pm 4$  k $\Omega$  and  $R_{in} = 500 \pm 2$   $\Omega$

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11. From the preamble, determine the percentage error in the resultant voltage.  
a. 85 %                      b. 0.4 %                      c. 0.085 %                      d. 13 %
12. Determine the fractional error in the input resistance.  
a. 0.85                      b. 0.004                      c. 0.00085                      d. 0.13
13. Find the percentage error in the feedback resistor.  
a. 85 %                      b. 0.4 %                      c. 0.085 %                      d. 13 %
14. Determine the percentage value of the error associated with the output voltage.  
a. 13.4085 %                      b. 98.004 %                      c. 98.4 %                      d. 13.485 %
15. The output voltage is given as:  
a.  $470 \pm 63.38$  V                      b.  $470 \pm 462.48$  V                      c.  $470 \pm 460.62$  V                      d.  $470 \pm 63.02$  V
16. Which of these are examples of open loop system:  
a. door lock system                      b. thermostat heater                      c. voltage stabilizer                      d. electric hand drier
17. All these are advantages of open loop system except:  
a. simple to design                      c. more accurate than counterpart system  
b. unaffected by external noise                      d. easy to maintain
18. How close repeated measurements are to each other represents the:  
a. stability                      b. accuracy                      c. reliability                      d. precision
19. Determine the output of a derivative controller having a derivative constant  $K_D$  of 0.4 s and a change in error of 2% /s.  
a. 0.4 %                      b. 0.2 %                      c. 0.6 %                      d. 0.8 %
20. How close the measurement is to the true (accepted) value is referred to as:  
a. stability                      b. accuracy                      c. reliability                      d. precision
21. What is the controller gain of a temperature controller with a 60% (Proportional Band) PB if its input range is  $0^\circ\text{C}$  to  $50^\circ\text{C}$  and its output is 4 mA to 20 mA?.  
a.  $0.0035$  A/ $^\circ\text{C}$                       b.  $0.00049$  A/ $^\circ\text{C}$                       c.  $0.00053$  A/ $^\circ\text{C}$                       d.  $0.00095$  A/ $^\circ\text{C}$

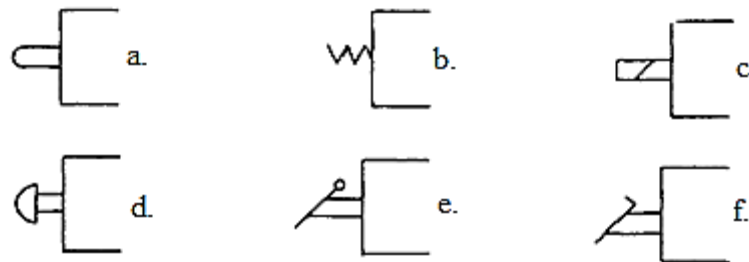
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*Answer true or false to the following statements.*

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22. In a direct action process controller element, increase in input gives an increase in output.  
23. An air conditioner is a direct action process element.  
24. PD control can deal with fast process changes better than proportional control only.  
25. A PID controller cannot eliminate offset error but can reduce time lags.

1. Distinguish between Systematic and Random errors. Give an example of each type of error. [4 Marks]
2. Mention 5 factors to be considered in selecting an appropriate transducer. [5 Marks]
3. A good sensor obeys the following two rules. [2 Marks]
4. Identify the following valve actuating methods. [6 Marks]



5. Taking the density of water as 1000 kg/m<sup>3</sup>, determine the valve size for a valve that is required to control the flow of water when the maximum flow rate required is 0.022 m<sup>3</sup>/s and the permissible pressure drop across the valve at this flow rate is 360 kPa. [4 Marks]

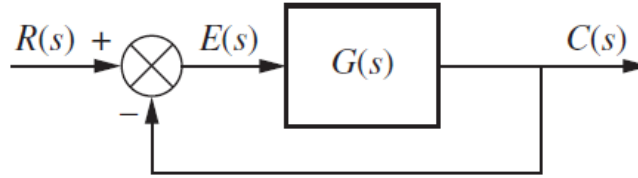
$$A_v = Q \sqrt{\frac{\rho}{\Delta p}}$$

Flow coefficients	Valve size in mm							
	480	640	800	960	1260	1600	1920	2560
$C_v$	8	14	22	30	50	75	110	200
$A_v \times 10^{-5}$	19	33	52	71	119	178	261	474

6. Mention 2 Ghanaian societies and 2 international societies responsible for ensuring standard measurements and representations. [4 Marks]
7. A hydraulic cylinder is to be used in a manufacturing operation to move a workpiece through a distance of 250 mm in 20 s. If a force of 50 kN is required to move the workpiece, what is the required pressure difference. [3 Marks]
8. From question 7, determine the hydraulic liquid flow rate if a cylinder with a piston diameter of 160 mm is to be used? [3 Marks]
9. Mention 1 reference material by title or by author that was beneficial to this course. [2 Marks]
10. What type of transducer is applied in the loudspeaker where an energized coil finds itself in a magnetic zone with paper or fabric made to vibrate back and forth. [2 Marks]

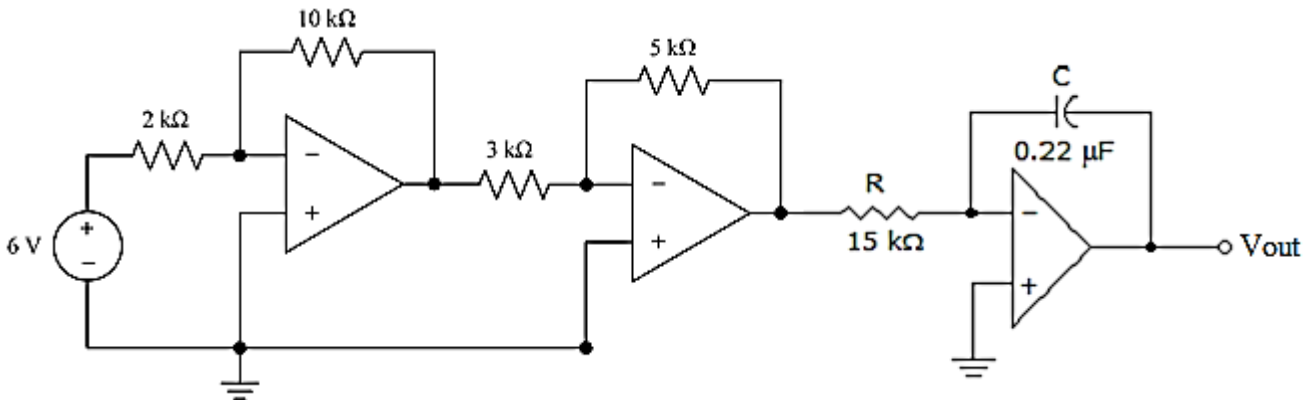
1. For the unity feedback system shown in the figure below, where  $G(s)$  is given by:

$$G(s) = \frac{60(s + 3)(s + 4)(s + 8)}{s^2(s + 6)(s + 17)}$$



Find the steady-state error if the input is  $50u(t)$ ,  $50tu(t)$ , and  $80t^2u(t)$ . [12 Marks]

2. Using a 5-bit parallel output shift register DAC, convert the digital word output of a measuring instrument given as 10101 to analogue voltage if the active voltage of the terminals of the digital device is 12 V. [15 Marks]
3. The signal conditioning device shown below is applied to amplify a weak signal of 6V output from a sensor. Determine the output signal strength (in volts) derived from the signal conditioning circuit. [10 Marks]



4. Draw a control loop block diagram to indicate an output rotating motor shaft with a differential amplifier controller, where the input value to the comparator is maintained by a potentiometer setting. Show in your diagram the correction element, process, the measurement and feedback linkage as the as the control law fed by the error signal. [6 Marks]
5. A mining industrial online instrument that records density, flow rate and slurry temperature, was observed to have given average false readings of  $9.25 \times 10^{-5}$  failures/day. Express the failure rate as failures/year. Assuming constant failure rate, determine the percentage reliability (to 2 decimal places) within the second year of observation of the instrument. [7 Marks]