Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2018/2019

COURSE NAME	:	INSTRUMENTATION AND MEASUREMENT
COURSE CODE	:	BEH 10102
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	DECEMBER 2018/ JANUARY 2019
DURATION	:	2 HOUR 30 MINUTES
INSTRUCTION	:	ANSWERS **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **SEVEN (7)** PAGES

Q1 (a) (i) Describe "static characteristic" of an instrumentation.

(2 marks)

(ii) Define the term "sensitivity" and "linearity" for any measuring instrument.

(3 marks)

(b) Identify the key differences between DC and AC bridges.

(5 marks)

(c) A Wheatstone Bridge as in **Figure Q1(c)** has $R_1 = 1000\ \Omega$, $R_2 = 4000\ \Omega$, $R_3 = 100\ \Omega$ and $R_4 = 400\ \Omega$ when the bridge is balanced. The internal resistance of the galvanometer is 100 Ω with its measuring sensitivity of 100 mm/μA. Determine the deflection (mm) of the galvanometer caused by an additional of 1 Ω in resistor R_4 when E = 10V.

(10 marks)

(d) The impedances of the AC bridge in **Figure Q1(d)** are given as follows:

$$Z_1 = 200 \angle 30° \ \Omega$$
$$Z_2 = 150 \angle 0° \ \Omega$$
$$Z_3 = 250 \angle -40° \ \Omega$$
$$Z_x = Z_4 = \text{unknown}$$

Determine the impedance of the unknown arm when the bridge is balanced.

(5 marks)

Q2 (a) List **FIVE (5)** selection criteria for each component below;

(i) Selection of transducer classification.

(5 marks)

(ii) Selection criteria of a sensor.

(5 marks)

(b) A strain gauge with gauge factor, GF = 2.03 and active gauge, $R_A = 350\ \Omega$ is used in the bridge of **Figure Q2(b).** The bridge resistors are $R_1 = R_2 = 350\ \Omega$, and the dummy gauge has $R_D = 350\ \Omega$. If a tensile strain of 1450 μm/m is applied;

(i) Determine the relation between bridge off-null voltage and strain.

(5 marks)

(ii) Find the bridge offset voltage if $V_s = 10$ V.

(5 marks)

(c) During experiment with a copper-constantan thermocouple, it was found that $c = 3.75 \times 10^{-2}$ mV/°C and $k = 4.50 \times 10^{-5}$ mV/°C. If $T_1 = 100$ °C and the cold junction T_2 is kept in the ice, compute the resultant electromotive force, emf.

(5 marks)

Q3 (a) Linear variable differential transformer (LVDT) and synchro measure position and displacement of an object.

(i) Distinguish the difference of LVDT with synchro.

(5 marks)

(ii) Describe the advantages of LVDT over linear potential meters.

(5 marks)

(b) The worktable of a positioning system as shown in the **Figure Q3(b)** is driven by a ball screw whose pitch is 25 mm. The ball screw is connected to the shaft of a stepper motor through a gearbox. An incremental encoder of 100 pulses/rev is connected to the end of the ball screw. The table must move a distance of 250 mm from its present position.

(i) Suggest the connection of an incremental encoder for the use of detecting forward and reverse motions with the help of a diagram.

(4 marks)

(ii) Calculate the resolution of the encoder.

(3 marks)

(iii) Calculate how many pulses of the encoder are to be read to identify that the table is moved to the specified distance.

(3 marks)

(c) An accelerometer in **Figure Q3(c)** has a seismic mass of 0.05 kg and a spring constant of 3.0×10^3 N/m. Maximum mass displacement is ± 0.02 m (before the mass hits the stops). Assuming friction is ignored, find;

(i) The maximum measurable acceleration in g.

(3 marks)

(ii) The natural frequency, f_N.

(2 marks)

Q4 (a) List **TWO (2)** advantages and **TWO (2)** disadvantages of a digital meter compared to analog meter.

(5 marks)

(b) A measurement of temperature using a sensor that outputs 6.5 mV/°C must measure up to 100 °C. A 6-bit ADC with a 10 V reference is used.

(i) Determine the required gain that needs to develop a circuit to interface the sensor and the ADC.

(5 marks)

(ii) Sketch the circuit.

(5 marks)

(iii) Analyse the temperature resolution.

(5 marks)

(c) A sensor signal is converted to a frequency that varies from 2 kHz to 20 kHz. This signal is to be converted into a 8-bit digital signal.

(i) Specify the count time, T_c.

(3 marks)

(ii) Analyse the range of count output for the frequency range of sensor signal.

(2 marks)

-END OF QUESTIONS –

FINAL EXAMINATION

SEMESTER / SESSION	: SEM I / 2018/2019	PROGRAMME CODE	: BEJ
COURSE NAME	: INSTRUMENTATION AND MEASUREMENT	COURSE CODE	: BEH 10102

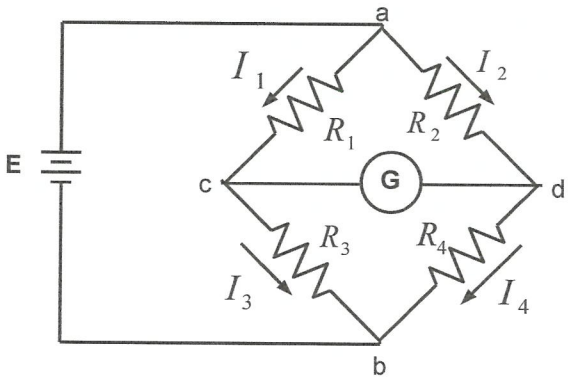

Figure Q1(c)

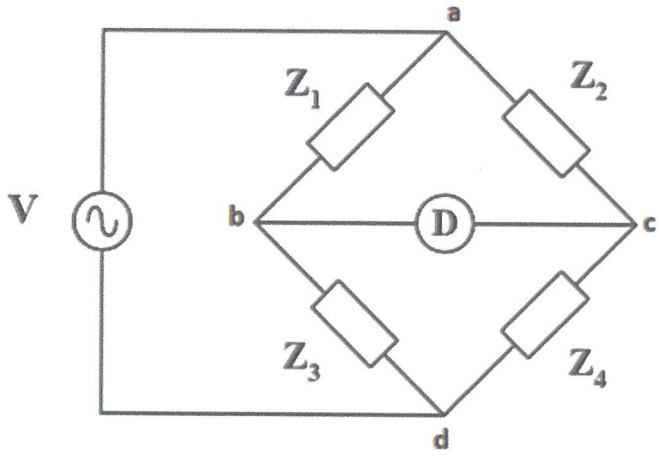

Figure Q1(d)

FINAL EXAMINATION

SEMESTER / SESSION	: SEM I / 2018/2019	PROGRAMME CODE	: BEJ
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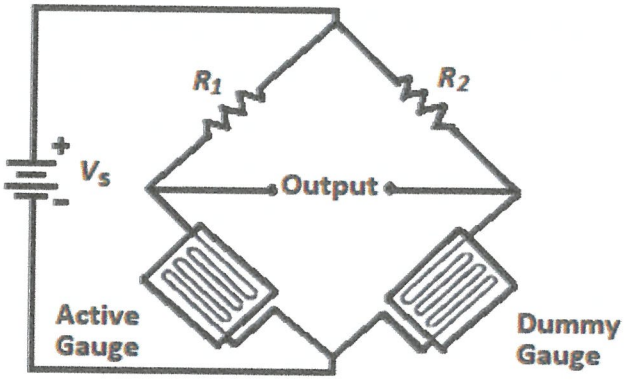

Figure Q2(b)

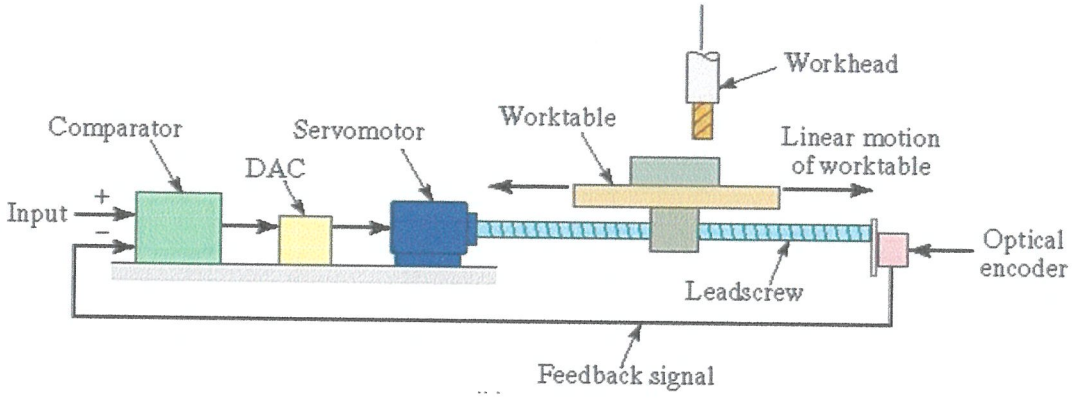

Figure Q3(b)

FINAL EXAMINATION

SEMESTER / SESSION	: SEM I / 2018/2019	PROGRAMME CODE	: BEJ
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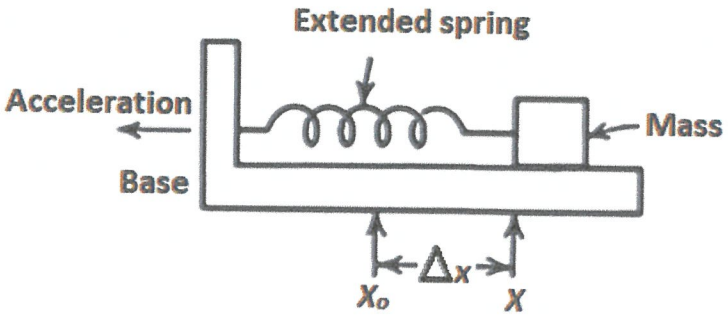

Note:

k = spring constant in N/m
Δ_x = spring extension in m
m = mass in Kg
a = acceleration in m/s^2

Figure Q3(c)