KOLEJ YAYASAN PELAJARAN JOHOR

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FINAL EXAMINATION

COURSE NAME	:	**INSTRUMENTATION AND MEASUREMENT**
COURSE CODE	:	**DEE 1053**
EXAMINATION	:	**JUNE 2024**
DURATION	:	**2 HOURS 30 MINUTES**

INSTRUCTION TO CANDIDATES /
ARAHAN KEPADA CALON

1. This examination paper consists of **FIVE (5)** questions. Answer **ALL** questions. /
*Kertas soalan ini mengandungi **LIMA (5)** soalan. Jawab SEMUA soalan.*

2. Candidates are not allowed to bring any material/note to the examination hall/room except with the permission from the invigilator. /
Calon tidak dibenarkan untuk membawa sebarang bahan/nota ke dewan/bilik peperiksaan tanpa kebenaran daripada pengawas.

3. Please check to make sure that this examination pack consist of: /
Pastikan kertas soalan peperiksaan ini mengandungi:

   i. The Question Paper /
   Kertas Soalan
   ii. An Answering Booklet /
   Buku Jawapan
   iii. Attachment 1 /
   Lampiran 1

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO /
JANGAN BUKA KERTAS SOALAN INI SEHINGGA DIBERITAHU

This examination paper consists of **10** printed pages including front page
*Kertas soalan ini mengandungi **10** muka surat termasuk kulit hadapan*

This part contains **FIVE (5)** questions. Answer **ALL** questions in the Answering Booklet.

*Kertas soalan ini mengandungi **LIMA (5)** soalan. Jawab **SEMUA** soalan di dalam Kertas Jawapan.*

QUESTION 1 / *SOALAN 1*

a) Calibration is the process of comparing and correcting the output of an instrument using standard instrument values. Explain **two (2)** advantages of calibration.

(4 marks/ *markah*)

b) Explain **two (2)** types of errors that exist in a measurement.

(4 marks/ *markah*)

c) Refer to **Figure 1**, calculate the power dissipated and the limiting error, if current 2.0 ± 0.01A flows through a 100 ± 0.2Ω resistor.

(12 marks/ *markah*)

*a) Tentukuran ialah proses membandingkan dan membetulkan keluaran sesuatu alatan menggunakan nilai alatan yang piawai. Terangkan **dua (2)** kebaikan tentukuran.*

*b) Terangkan **dua (2)** jenis ralat yang wujud dalam sesuatu pengukuran.*

*c) Merujuk **Rajah 1**, kirakan kuasa terlesap dan ralat mengehad, jika arus bernilai 2.0 ± 0.01A mengalir melalui perintang 100 ± 0.2Ω.*

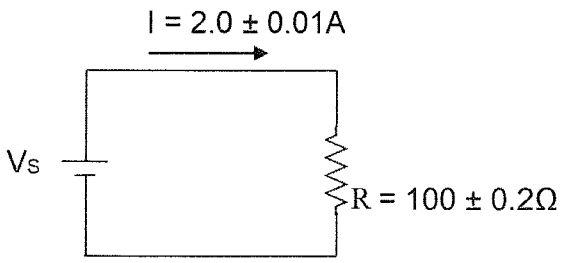

Figure 1 / *Rajah 1*

QUESTION 2 / *SOALAN 2*

a) A 100 μA full scale deflection current meter movement is used in an Ayrton multi-range ampere meter circuit. The meter movement has an internal resistance, R_m = 2 kΩ. Determine the value of the shunt resistance, if the meter has a range of 25 mA, 65 mA and 100mA.

(10 marks/ *markah*)

b) **Figure 2** shows a full-wave rectifier type AC meter with a range of 1 V. The diodes have a forward resistance each of 100 Ω while the parameters of the d'Arsonval movement are 50 μA, 200 Ω. It is required that $I_{sh} = I_m$.

i. Calculate the shunt resistor, R_{sh}.

ii. Calculate the multiplier resistor, R_s.

iii. Calculate the AC sensitivity of the meter, S_{ac}.

(10 marks/ *markah*)

a) Gerakan meter arus pesongan skala penuh 100 μA digunakan dalam litar meter ampere berbilang julat pirau Ayrton. Gerakan meter tersebut mempunyai rintangan dalam, R_m = 2 kΩ. Tentukan nilai rintangan pirau, jika meter tersebut mempunyai julat 25 mA, 65 mA dan 100mA.

*b) **Rajah 2** menunjukkan meter AU jenis penerus penuh-gelombang berjulat 1 V. Setiap diod mempunyai rintangan ke depan 100 Ω sementara parameter gerakan d'Arsonval ialah 50 μA, 200 Ω. Dikehendaki supaya $I_{sh} = I_m$.*

i. Kirakan rintangan pirau, R_{sh}.

ii. Kirakan rintangan pendarab, R_s.

iii. Kirakan kepekaan AU meter, S_{au}.

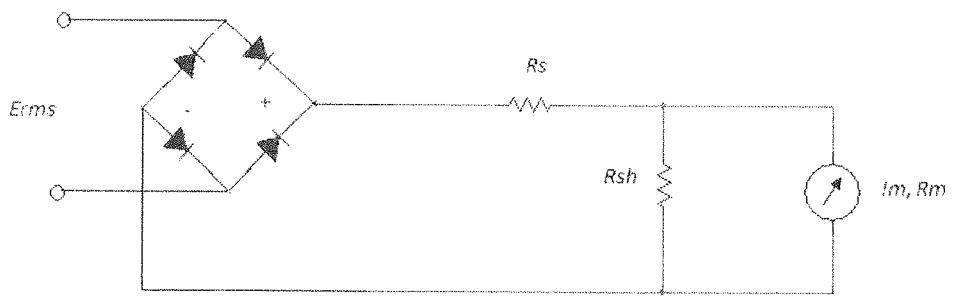

Figure 2 / *Rajah 2*

QUESTION 3 / *SOALAN 3*

a) Briefly explain **four (4)** advantages of a digital voltmeter as compared to an analogue voltmeter.

(12 marks/ *markah*)

b) An analogue-to-digital converter uses an integrator in its input part.

i. Sketch an integrator circuit with a resistor 10 kΩ and a capacitor 10 μF.

ii. If the integrator input voltage is 1 V, calculate the integrator output voltage after 0.1 second.

iii. Sketch the form of the integrator output voltage.

(8 marks/ *markah*)

*a) Terangkan dengan ringkas **empat (4)** kelebihan meter volt digital berbanding dengan meter volt analog.*

b) Penukar analog-ke-digit menggunakan pengamir pada bahagian masukan litar.

i. Lakarkan litar pengamir dengan nilai perintang 10 kΩ dan pemuat 10 μF.

ii. Jika voltan masukan pengamir ialah 1 V, kirakan voltan keluaran pengamir tersebut selepas 0.1 saat.

iii. Lakarkan bentuk voltan keluaran pengamir.

QUESTION 4 / *SOALAN 4*

a) With the aid of diagrams, explain **two (2)** transducer functions.

(6 marks/ *markah*)

b) **Figure 3** shows the LVDT and its specification.

i. Explain briefly the operation of the LVDT.

ii. Calculate the displacement if the output voltage is 2.5 mV.

iii. Sketch the graph of the output voltage versus displacement if the output of the LVDT is at the range of -4 mV to +2.5 mV.

(14 marks/ *markah*)

*a) Dengan bantuan gambar rajah, terangkan **dua (2)** fungsi transduser.*

*b) **Rajah 3** menunjukkan LVDT dan spesifikasinya.*

i. Terangkan dengan ringkas prinsip pengendalian LVDT.

ii. Kirakan anjakan jika voltan keluaran ialah 2.5 mV.

iii. Lakarkan graf voltan keluaran melawan anjakan jika keluaran LVDT pada julat -4 mV hingga +2.5 mV.

The specification of LVDT is as follow: ***Spesifikasi LVDT ialah seperti berikut :***	
Input voltage / *Voltan masukan*	: 10 V
Output voltage / *Voltan keluaran*	: ±5 mV
Displacement range / *Julat anjakan*	: ±5 inch

Figure 3 / *Rajah 3*

QUESTION 5 / *SOALAN 5*

a) This question is related to Wien bridge circuit.

i. Sketch the circuit of Wien bridge circuit.

ii. Prove that when the bridge is balanced:

$$\frac{R1}{R3} + \frac{C3}{C1} = \frac{R2}{R4}$$

$$f = \frac{1}{2\pi\sqrt{C1\ C3\ R1\ R3}}$$

iii. The frequency calculated using the Wien AC bridge is 40 Hz. If R_1 = 400 Ω, C_1 = 5.5 μF and R_3 = R_4 =1 kΩ. Calculate C_3 and R_2.

(14 marks/ *markah*)

b) List down **three (3)** features of RS232.

(6 marks/ *markah*)

a) Soalan ini berkaitan dengan litar titi Wien.

i. Lukiskan litar bagi titi Wien.

ii. Buktikan bahawa titi seimbang apabila:

$$\frac{R1}{R3} + \frac{C3}{C1} = \frac{R2}{R4}$$

$$f = \frac{1}{2\pi\sqrt{C1\ C3\ R1\ R3}}$$

iii. Frekuensi yang dikira dengan menggunakan titi Wien adalah 40 Hz. Jika R_1 = 400 Ω, C_1 = 5.5 μF dan R_3 = R_4 = 1 kΩ. Kirakan C_3 and R_2.

*b) Senaraikan **tiga (3)** ciri RS232.*

[100 MARKS / MARKAH]

END OF QUESTION PAPER / *KERTAS SOALAN TAMAT*

Attachment 1 / *Lampiran 1*

Measurement and Error / *Ralat dan Pengukuran*

Absolute Error, e ***Ralat Mutlak, e***	$Yn - Xn$	**Standard Deviation** ***Sisihan Piawaian***	$\sigma = \sqrt{\dfrac{\sum_{k=1}^{n} d_k^2}{n-1}}$
Percent Error, %e ***Peratus Ralat,% e***	$\dfrac{e}{Yn} \; x\,100\%$	**Deviation** ***Sisihan***	$d_1 = x_1 - \bar{x}$ $d_2 = x_2 - \bar{x}$ $d_3 = x_3 - \bar{x}$ . . . $d_n = x_n - \bar{x}$
Accuracy, a ***Kejituan, a***	$100\% - \text{Peratus ralat}$	**Average deviation** ***Sisihan purata***	$D = \dfrac{\sum_{k=1}^{n} \lvert d_k \rvert}{n}$
Precision ***Kepersisan***	$1 - \left\lvert \dfrac{X_n - \bar{X}}{\bar{X}} \right\rvert$	**Arithmetic mean / average** ***Purata / min aritmetik***	$\bar{x} = \dfrac{\sum_{k=1}^{n} x_k}{n}$
Combined Measurement Error ***Gabungan ralat pengukuran***			

Operasi matematik	Ralat gabungan
$C = A + B$	$\Delta C = \pm(\Delta A + \Delta B)$
$C = A - B$	$\Delta C = \pm(\Delta A + \Delta B)$
$C = A \times B$	$\%C = \pm(\%A + \%B)$
$C = A/B$	$\%C = \pm(\%A + \%B)$

Analog Meter / *Meter Analog*

Shunt Resistance ***Rintangan Pirau***	$R_{sh} = \frac{V_{sh}}{I_{sh}} = \frac{I_m R_m}{I_{sh}} = \frac{I_m}{I_{sh}} R_m = \frac{I_m}{I - I_m} \times R_m$ **Where :** $I = nI_m$ ***Dimana***
Aryton Shunt Ampere Meter ***Meter Ampere Pirau Aryton***	$R_b + R_c = \frac{I_m (R_{sh} + R_m)}{I_2}$ $R_a = R_{sh} - (R_b + R_c)$ $R_c = \frac{I_m (R_{sh} + R_m)}{I_3}$
Sensitivity ***Kepekaan***	$\text{Kepekaan} = \frac{1}{I_{sp}} (\Omega/\text{V})$
Aryton Shunt Voltage Meter ***Meter Voltan Pirau Aryton***	$R_a = S \times \text{Julat} - R_m$ $R_b = S \times \text{Julat} - (R_a + R_m)$ $R_c = S \times \text{Julat} - (R_a + R_b + R_m)$
Half-wave Rectifier and Full-wave Rectifier ***Penerus Separuh Gelombang dan Penerus Gelombang Penuh***	$S_{au} = 0.45\ S_{at}$ **or** $S_{au} = 0.9\ S_{at}$ **Where:** ***Dimana*** $S_{at} = \frac{1}{I_T}$ $S_{au} = \frac{R_T}{\text{Julat}}$ $R_s = R_T - R_d - \frac{R_m R_{sh}}{R_m + R_{sh}}$ $R_s = R_T - 2R_d - \frac{R_m R_{sh}}{R_m + R_{sh}}$ **Where :** ***Dimana*** $I_{sh} = \frac{E_m}{R_{sh}}$ $I_T = I_{sh} + I_m$ $E_{at} = 0.45\ \text{Vpmkd}$ or $0.9 \times \text{Vpmkd}$ $R_T = \frac{E_{at}}{I_T}$

Digital Instruments / *Alatan Digital*

Single Slope Converter Techniques ***Teknik Penukar Satu Cerun***	$V_x = V_{ref} \times \frac{t_1}{t_1 + t_2}$ Bilangan denyut $= t \times f$
Dual Slope Converter Techniques ***Teknik Penukar Dua Cerun***	**Capasitor Charging** ***Pemuat Mengecas*** $V_A = V_i \frac{t_2 - t_1}{RC}$ **Capasitor Charging** ***Pemuat Mengecas*** $V_A = V_{ref} \frac{t_3 - t_2}{RC}$
Voltage to Frequency Converter Techniques ***Teknik Penukar Voltan ke Frekuensi***	$V_i = \frac{f}{50}$ $f = \frac{\text{Bilangan denyut}}{\text{Masa denyutan}}$

Transducers / *Tranduser*

Strain Gauge ***Tolok Terikan***	$K = \frac{\Delta R/R}{\Delta l/l}$ $G = \frac{\Delta l}{l}$ $F = SA$ $\Delta R = KRG$ $S = GE$
Linear Variable Displacement Transducer (LVDT) ***Pengubah Kebezaan Boleh Ubah Lelurus (LVDT)***	$v_o = v_1 - v_2$ V_o = Kepekaan x V_{in} x Anjakan
Thermocouple ***Pengganding Suhu***	$V_m = V_o + V_r$ $V_o = AT^2 + BT^2$
Resistance Temperature Detector (RTD) ***Pengesan Suhu Rintangan (RTD)***	$R = R_o(1 + \alpha\Delta T)$
Termistor ***Suhu Rintangan***	$R = R_o e^{\beta\left(\frac{1}{T} - \frac{1}{To}\right)}$

Signal Conditioning / *Penyesuaian Isyarat*

<table>
<tr><td colspan="3">Direct Current Bridge
Titi Arus Terus</td></tr>
<tr><td>Wheatstone Quarter Bridge
Titi Suku Wheatstone</td><td>Wheatstone Half Bridge
Titi Separuh Wheatstone</td><td>Wheatstone Full Bridge
Titi Penuh Wheatstone</td></tr>
<tr><td>$\frac{\Delta R}{4R} E$</td><td>$\frac{\Delta R}{2R} E$</td><td>$\frac{\Delta R}{R} E$</td></tr>
<tr><td colspan="3">Alternatif Current Bridge
Titi Arus Ulang Alik</td></tr>
<tr><td colspan="2">Maxwell Bridge
Titi Maxwell</td><td>Hay Bridge
Titi Hay</td></tr>
<tr><td colspan="2">$\frac{1}{Z_1} = \frac{1}{R_1} + j\omega C_1$
$Z_2 = R_2$
$Z_3 = R_3$
$Z_x = R_x + j\omega L_x$</td><td>$Z_1 = R_1 + \frac{1}{j\omega C_1}$
$Z_2 = R_2$
$Z_3 = R_3$
$Z_x = R_x + j\omega L_x$</td></tr>
<tr><td colspan="2">Schering Bridge
Titi Schering</td><td>Wien Bridge
Titi Wien</td></tr>
<tr><td colspan="2">$\frac{1}{Z_1} = \frac{1}{R_1} + j\omega C_1$
$Z_2 = R_2$
$Z_3 = \frac{1}{j\omega C_3}$
$Z_x = R_x + \frac{1}{j\omega C_x}$</td><td>$Z_1 = R_1 + \frac{1}{j\omega C_1}$
$Z_2 = R_2$
$\frac{1}{Z_3} = \frac{1}{R_3} + j\omega C_3$
$Z_4 = R_4$</td></tr>
</table>