UNIVERSITI SAINS MALAYSIA

Second Semester Examination
Academic Session 2007/2008

April 2008

ZAT 283/3 – Instrumentation
[Instrumentasi]

Duration: 3 hours
[Masa : 3 jam]

Please ensure that this examination paper contains **TEN** printed pages before you begin the examination.

*[Sila pastikan bahawa kertas peperiksaan ini mengandungi **SEPULUH** muka surat yang bercetak sebelum anda memulakan peperiksaan ini.]*

Instruction: Answer **all four (4)** questions. Students are allowed to answer all questions in Bahasa Malaysia or in English.

*[**Arahan**: Jawab **semua empat (4)** soalan. Pelajar dibenarkan menjawab semua soalan sama ada dalam Bahasa Malaysia atau Bahasa Inggeris.]*

.../2-

Test Load (kg)	Actual Output (mV)	Desired Output (mV)
0	1.2	0
1.5	30.6	53.3
3.0	89.4	106.7
4.5	144.6	160.0
6.0	200.0	213.4
7.5	259.0	266.7
9.0	317.6	320.0
10.5	375.8	373.0

Table 1 *[Jadual 1]*

1. (a) Refer to Table 1. A physicist found that a weighting scale is giving erroneous weight measurements. She performed calibration on the scale's load cell and recorded the results as in Table 1.
[Rujuk kepada Jadual 1. Seorang ahli fizik mendapati penimbang berat memberikan pengukuran berat yang salah. Beliau membuat kalibrasi untuk muatan sel penimbang dan merekod data seperti dalam Jadual 1.]

(i) Determine the accuracy as a percentage of the full scale output.
[Tentukan ketepatan sebagai peratus dari skalar penuh output]

(ii) Determine the accuracy as a percentage of the reading.
[Tentukan ketepatan sebagai peratus bacaan.]

(iii) Determine the absolute error.
[Tentukan ralat sebenar]

(40/100)

(b) A student constructed a temperature-controlled system to maintain the temperature of an oven at 1000 ± 10°C. He used a thermocouple sensor, an operational amplifier, a power relay-switch and a programmable logic controller (PLC). Draw a block diagram that represents a good temperature control system. Include these elements - comparison, control, correction, process and measuring. Label the blocks correctly.

[Seorang pelajar membina suatu sistem kawalan suhu untuk mengawal suhu oven pada tahap 1000 ± 10°C. Dia menggunakan termogandingan, amplifier pengoperasi, suis kuasa relay dan pengawal logik programan (PLC). Lakar satu gambarajah blok yang mewakili sistem kawalan suhu yang baik. Selitkan unsur-unsur berikut – perbandingan, pengawal, pembetulan, proses dan pengukuran. Labelkan blok dengan betul]

(30/100)

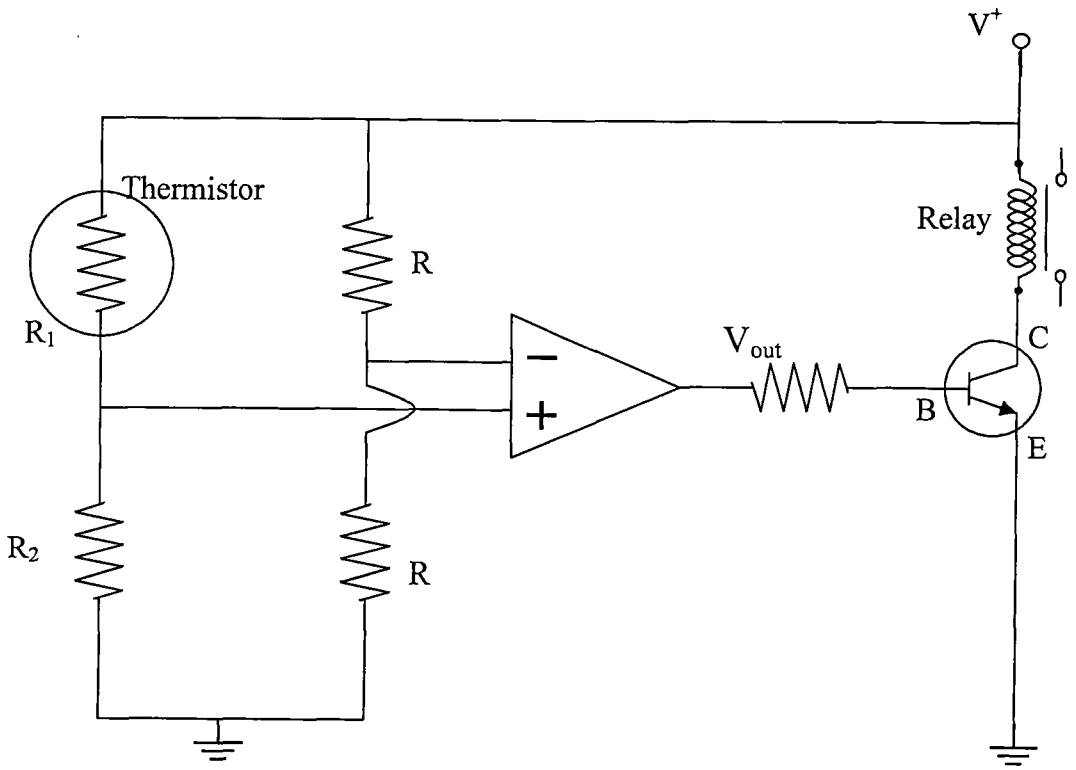

Figure 1 *(Rajah 1)*

(c) Figure 1 shows a room-temperature switch circuit that employs a Wheatstone bridge with a thermistor.
[Rajah 1 menunjukkan satu litar suis suhu-bilik yang menggunakan jejambat Wheatstone dan termistor]

(i) In less than 100 words, explain what will happen to the transistor and relay if the room temperature is lower than the critical temperature of the circuit.
[Terangkan, dengan tidak lebih daripada 100 patah perkataan, apa yang akan berlaku kepada transistor dan relay jika suhu bilik lebih rendah daripada suhu genting litar.]

(ii) In less than 100 words, explain what will happen to the transistor and relay if the room temperature is higher than the critical temperature of the circuit.
[Dengan tidak melebihi 100 patah perkataan, terangkan apa yang akan berlaku kepada transistor dan relay jika suhu bilik adalah lebih tinggi daripada suhu kritikal litar.]

(30/100)

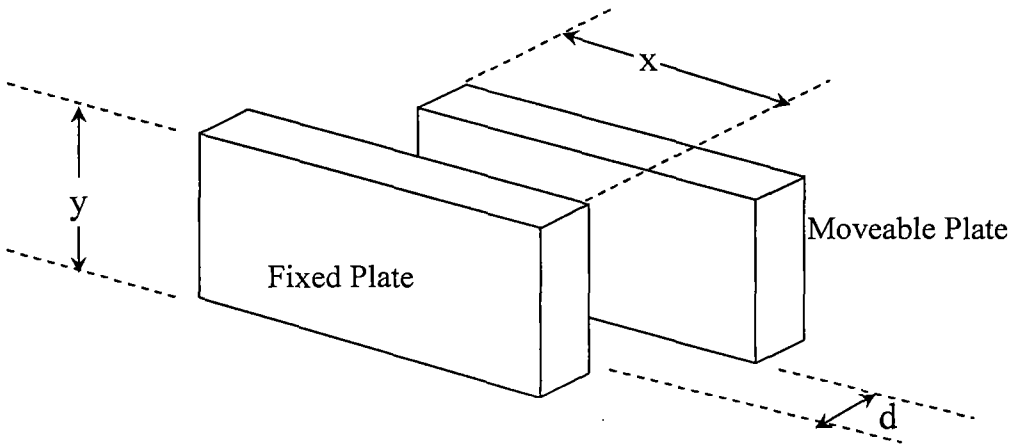

Figure 2 *[Rajah 2]*

2. (a) A final year student built a capacitive displacement sensor using two conducting plates as shown in Figure 2. One of the plates is moveable while the other is fixed. The plates are separated by a distance "d" of air.
[Seorang pelajar tahun akhir membina satu pengesan sesaran kapasitan menggunakan dua plat penkonduk seperti dalam Rajah 2. Satu plat boleh digerakkan manakala plat satu lagi tidak bergerak. Plat tersebut dipisahkan oleh udara pada jarak "d"]

(i) Derive an expression that gives the distance "x" in terms of total capacitance "C".
[Bina satu unkapan yang memberikan jarak "x" dalam bentuk jumlah kapasitan "C"]

(ii) Derive an expression that gives the distance "x" in terms of charge "q" and voltage "v".
[Bina satu ungkapan yang memberikan jarak "x" dalam bentuk cas "q" dan voltan "v"]

(30/100)

2. (b) An analog-to-digital converter (ADC) has a word length of 8 bits and analog-signal input range of 10 V.
[Satu penukar analog ke digital (ADC) mempunyai panjang perkataan 8 bit dan julat isyarat analog input 10V.]

(i) Determine the device resolution.
[Tentukan resolusit peranti]

(ii) If input signal is amplified seven times before being fed to the ADC, what would be the new device resolution?
[Jika isyarat input digandakan tujuh kali sebelum disalurkan kepada ADC, apakah resolusi baru peralatan?]

(30/100)

2. (c) An engineer built a simple incremental optical encoder to measure angular displacement. He used a slotted disc, LEDs and photodetectors.
[Seorang jurutera membina satu encoder optik menaik yang ringkas untuk mengukur sesaran sudut.. Beliau menggunakan cakera berlubang, LEDs dan pengesanfoto.]

(i) Using schematic diagrams and less than 100 words, describe how the optical encoder works.
[Menggunakan gambarajah skematik dan tidak melebihi 100 patah perkataan, jelaskan bagaimana penyahkod optik berfungsi.]

(ii) Using schematic diagrams and less than 100 words, describe how the engineer can determine either the angular rotation is clockwise or counterclockwise.
[Menggunakan gambarajah skematik dan tidak lebih daripada 100 perkataan, jelaskan bagaimana jurutera tersebut boleh menentukan samaada enkodur optik berputar mengikut arah jam atau lawan jam]

(40/100)

3. (a) A thermocouple sensor produced an output voltage in the range from 0 to 30 mV. Design and sketch an inverting amplifier circuit that produces an output voltage with a range from 0 to -6 V. Use an input resistor rated at 10 kΩ.
[Satu termogandingan menghasilkan voltan output dalam lingkungan 0 hingga 30 mV. Rekabentuk dan lakarkan satu litar amplifier songsang yang menghasilkan voltan output pada julat daripada 0 hingga -6 V. Gunakan perintang input berkadar 10 kΩ.]

(30/100)

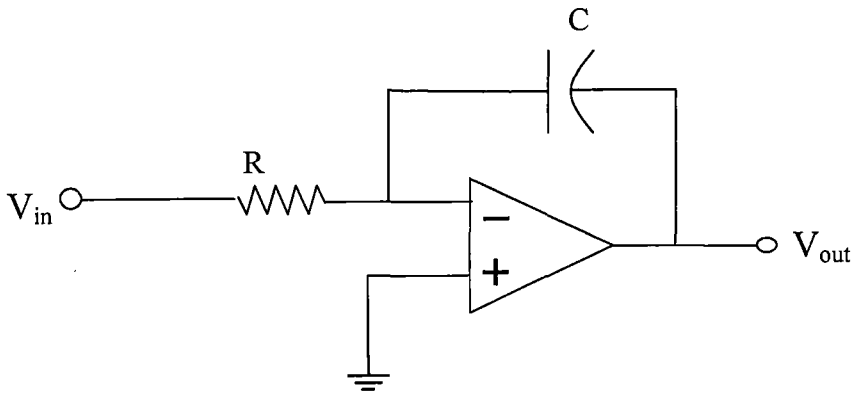

Figure 3 *(Rajah 3)*

3. (b) Refer to Figure 3.
[Rujuk kepada Rajah 3]

(i) Give the correct name of the operational amplifier circuit in Figure 3.
[Berikan nama yang betul untuk litar amplifier pengoperasi dalam Rajah 3]

(ii) Calculate the value of capacitance if the output gives an output gradient of 200 mV/ms when the input voltage is a constant 8 V and the input resistance is 1 kΩ.
[Kira kapasitan jika output memberikan kecerunan 200 mV/ms tatkala voltan input adalah malar 8 V dan perintang input adalah 1 kΩ.]

(30/100)

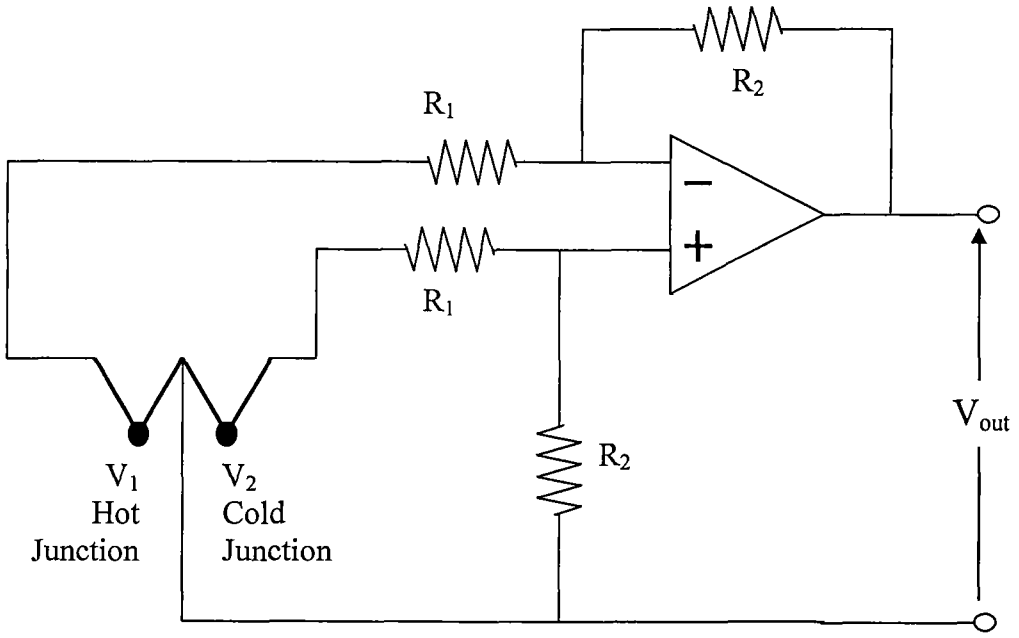

Figure 4 *(Rajah 4)*

3. (c) Referring to Figure 4, a differential amplifier amplifies the signal from a thermocouple sensor that has a sensitivity of 0.1 mV/°C. If the temperature difference between the thermocouple junctions is 200°C, the output voltage should be 1 V.
[Merujuk kepada Rajah 4, satu amplifier pembeza menggandakan isyarat daripada thermogandingan yang mempunyai kepekaan 0.1 mV/°C. Jika perbezaan suhu antara simpangan termogandingan adalah 200 °C, voltan output hendaklah menjadi 1 V.]

(i) Write an equation that describes the relationship between resistors R_1 and R_2.
[Tuliskan satu persamaan yang menjelaskan hubungan antara R_1 and R_2]

(iii) If R_1 is 1 kΩ, determine R_2.
[Jika R_1 adalah 1 kΩ, tentukan R_2]

(40/100)

4. (a)

(i) Define data acquisition (DAQ).
[Takrifkan perolehan data (DAQ)]

(ii) What are the main components of DAQ?
[Apakah komponen utama DAQ?]

(iii) In less than 100 words, explain DAQ process.
[Dengan tidak melebihi 100 patah perkataan, terangkan proses DAQ]

(30/100)

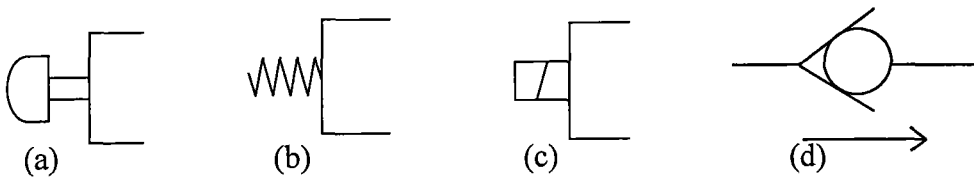

Figure 5 *(Rajah 5)*

4. (b)

(i) Give the names of the valve symbols in Figure 5.
[Berikan nama untuk symbol-simbol injap, dalam Rajah 5]

(ii) Define actuation power system.
[Berikan definisi sistem kuasa aktuator]

(iii) List down one advantage and one disadvantage of pneumatic actuators if compared with hydraulic actuators.
[Senaraikan satu kelebihan dan satu kekurangan aktuator pneumatic jika dibandingkan dengan aktuator hidrolik]

(30/100)

4. (c)

(i) Sketch a schematic diagram of a basic motor design for electric actuation, and in less than 100 words, explain how rotation is produced in the motor.
[Lakar gambarajah rekabentuk motor asas untuk aktuator elektrik, dan dengan tidak melebihi 100 patah perkataan, terangkan bagaimana putaran dihasilkan dalam motor.]

(ii) Give the name of a DC motor used to provide the highest starting torque and sketch a reasonable Torque-Speed graph for the motor.
[Namakan satu DC motor yang digunakan untuk menghasilkan tork permulaan yang tertinggi, dan lakarkan satu rajah Laju-Tork untuk motor tersebut.]

(40/100)

$$i = C\frac{dV}{dt}$$

$$V = L\frac{di}{dt}$$

$$\frac{V_s}{V_p} = \frac{N_2}{N_1} = \frac{i_p}{i_s}$$

$$e^{jx} = \cos(x) + j\sin(x)$$

$$Z = \frac{V}{I} = \frac{V_{RMS}}{I_{RMS}} = \sqrt{(X_L + X_C)^2 + R^2}$$

$$Z = \frac{V_c(t)}{i_c(t)} = R + jX = |Z|e^{j\theta_Z}$$

$$X_C = -\frac{1}{\omega C}$$

$$X_L = \omega L$$

$$Z_T = Z_1 + Z_2 + Z_3 + Z_4 + \ldots Z_N$$

$$\frac{1}{Z_T} + \frac{1}{Z_1} + \frac{1}{Z_2} + \frac{1}{Z_3} + \frac{1}{Z_4} + \ldots \frac{1}{Z_N}$$

$$\omega_0 = \frac{1}{\sqrt{LC}}$$

$$\tan\theta = \frac{X_L + X_C}{R}$$

$$P_{av} = \frac{VI}{2}\cos\theta = V_{RMS} I_{RMS} \cos\theta$$

$$P_c = \frac{1}{2}V_c(t)\,i_c^*(t) = P_{av} + jP_X$$

$$P_c = \frac{V_c(t)V_c^*(t)}{2Z^*} = \frac{i_c(t)Zi_c^*(t)}{2}$$

$$V_{out} = V_0 = A_0(v_2 - v_1)$$

$$\frac{V_0}{V_{in}} = -\frac{R_2}{R_1}$$

$$\frac{V_0}{V_{in}} = 1 + \frac{R_2}{R_1}$$

$$V_o = -R_f \sum_{n=1}^{N} \frac{V_{bn}}{R_n}$$

$$V_o = \left(1 + \frac{R_f}{R_d}\right)\frac{1}{M}\sum_{m=1}^{M} V_{am}$$

$$V_0 = -\frac{1}{RC}\int_0 V_{in}\,dt$$

$$V_0 = -RC\frac{dV_{in}}{dt}$$

$$V_O = -C\ln\left(\frac{V_{in}}{R}\right) = K\ln V_{in}$$

$$V_O = \frac{R_2}{R_1}(V_2 - V_1)$$

$$\text{CMRR} = \frac{A_0}{A_{cm}}$$

$$A(\omega) = \frac{A_0}{1 + j(\omega/\omega_b)}$$

$$\omega_u = \omega_b\sqrt{A_0^2 - 1}$$

$$\omega_B = \omega_b\frac{A_0}{1 + R_2/R_1}$$

$$T = NbbLi = k_t i$$

$$T = k_t i = \frac{k_t}{R}(V - k_v\omega)$$

$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$