UNIVERSITI MALAYSIA PERLIS

Peperiksaan Semester Pertama
Sidang Akademik 2025/2026

Januari-Februari 2026

EMK22003 – Control System Technology
[Teknologi Sistem Kawalan]

Masa : 2 jam

Please make sure that this question paper has **EIGHT (8)** printed pages including this front page before you start the examination.
*[Sila pastikan kertas soalan ini mengandungi **LAPAN (8)** muka surat yang bercetak termasuk muka hadapan sebelum anda memulakan peperiksaan ini.]*

This question paper has **FOUR (4)** questions. Answer **ALL** questions. Each question contributes 25 marks.
*[Kertas soalan ini mengandungi **EMPAT (4)** soalan. Jawab **KESEMUA** soalan. Markah bagi tiap-tiap soalan adalah 25 markah.]*

Appendix 1 is included.
*[**Lampiran 1** disertakan.]*

Dicetak oleh Unit Peperiksaan & Pengijazahan, Bahagian Pengurusan Akademik, Pusat Pengurusan Akademik UniMAP

Question 1
[Soalan 1]

The following items in **Table 1** consist of a missile launcher subsystem. The input, *R(s)* controls the rotation of the missile launcher, *Y(s)*.
*[Butiran-butiran berikut dalam **Jadual 1** terdiri daripada satu subsistem panduan luncuran. Masukannya, R(s) mengawal putaran panduan luncuran tersebut, Y(s).]*

Table 1
[Jadual 1]

Subsystem *[Subsistem]*	Value *[Nilai]*
Rotation *[Putaran]*	$R(s)$
Power amplifier *[Penguat kuasa]*	K
Motor *[Motor]*	$\frac{1}{(s+1)}$
Missile *[Luncuran]*	$Y(s)$

(a) Construct the open-loop system control scheme.
[Binakan skema kawalan sistem gelung-buka.]

(2 Marks/ *Markah*)

(b) Suggest and discuss improvement method by drawing the corresponding block diagram.
[Cadangkan dan bincangkan kaedah penambahbaikkan dengan melukis gambarajah blok yang sepadan.]

(6 Marks/ *Markah*)

(c) From **Question 1(a)**, obtain the open-loop function of the system, *G(s)* if $K = 5$.
*[Dari **Soalan 1(a)**, dapatkan rangkap pindah gelung-buka untuk sistem, G(s) jika K = 5.]*

(3 Marks/ *Markah*)

(d) From **Question 1(b)**, list advantages of improvement compared to open-loop system control scheme.
*[Dari **Soalan 1(b)**, senaraikan kelebihan-kelebihan penambahbaikkan jika dibandingkan dengan skema kawalan sistem gelung-buka.]*

(4 Marks/ *Markah*)

(e) List **ONE (1)** Sustainable Development Goals (SDG) that can be related to **Question 1(b)** and give an example of control strategy to support the achievement of that SDG.
*[Senaraikan **SATU (1)** Matlamat Pembangunan Mampan (SDG) yang boleh dikaitkan dengan **Soalan 1(b)** dan berikan satu contoh strategi kawalan untuk menyokong pencapaian SDG tersebut.]*

(10 Marks/ *Markah*)

Question 2
[Soalan 2]

A system of a high-speed valve is shown in **Figure 2(a)**. Based from figure below:
*[Satu sistem daripada satu injap berkadaran laju-tinggi seperti yang ditunjukkan dalam **Rajah 2(a)**. Berdasarkan rajah di bawah;]*

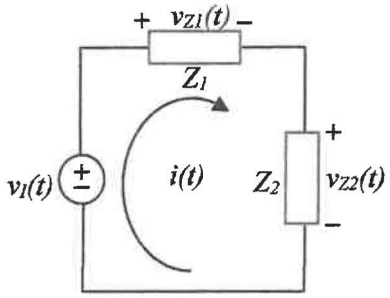


Figure 2(a)
[Rajah 2(a)]

(a) if Z_1 is a resistor and Z_2 is an inductor, derive the system transfer function, $G(s) = \frac{V_O(s)}{V_I(s)}$, when the applied voltage $v_I(t)$, is the input, $i(t)$ is the current and $v_O(t)$ is the output voltage at $v_{Z2}(t)$.
[jika Z_1 ialah perintang dan Z_2 ialah pengaruh, terbitkan rangkap pindah sistem tersebut, $G(s) = \frac{V_O(s)}{V_I(s)}$, apabila voltan kenaan $v_I(t)$, ialah masukan, $i(t)$ ialah arus dan $v_O(t)$ ialah voltan keluaran pada $v_{Z2}(t)$.]

(9 Marks/ *Markah*)

(b) if Z_1 is a resistor and Z_2 is a capacitor, derive the system transfer function, $G(s) = \frac{V_O(s)}{V_I(s)}$, when the applied voltage $v_I(t)$, is the input, $i(t)$ is the current and $v_O(t)$ is the output voltage at $v_{Z1}(t)$.
[jika Z_1 ialah perintang dan Z_2 ialah pemuat, terbitkan rangkap pindah sistem tersebut, $G(s) = \frac{V_O(s)}{V_I(s)}$, apabila voltan kenaan $v_I(t)$, ialah masukan, $i(t)$ ialah arus dan $v_O(t)$ ialah voltan keluaran pada $v_{Z1}(t)$.]

(9 Marks/ *Markah*)

(c) solve the circuit in **Figure 2(b)** for G(s) from **Question 2(a)** and if H(s) = 0.
*[selesaikan litar dalam **Rajah 2(b)** untuk G(s) dari **Soalan 2(a)** dan jika H(s) = 0.]*

(7 Marks/ *Markah*)

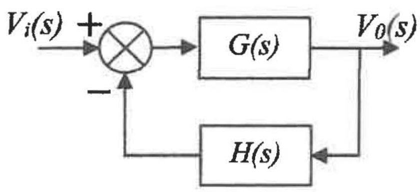


Figure 2(b)
[Rajah 2(b)]

Question 3
[Soalan 3]

A second-order system with unity feedback is given by the following transfer function, $G(s)$. Determine;
[Satu sistem tertib-kedua dengan suap balik unit diwakili oleh rangkap pindah, G(s) berikut. Tentukan:]

$$G(s) = \frac{10}{s^2 + 5s + 6}$$

(a) natural frequency, ω_n,
[frekuensi tabii, ω_n,]

(4 Marks/ *Markah*)

(b) gain, K,
[gandaan, K,]

(5 Marks/ *Markah*)

(c) damping factor, ξ.
[faktor redaman, ξ.]

(3 Marks/ *Markah*)

(d) comment on the system stability and its type of response.
[ulaskankan kestabilan sistem tersebut dan jenis sambutannya.]

(3 Marks/ *Markah*)

(e) the system G(s) is connected to a unity feedback system in **Figure 3**. Sketch the root locus for the system.
*[sistem G(s) disambungkan kepada sistem suap balik unit seperti dalam **Rajah** 3. Lakarkan londar punca sistem tersebut.]*

(10 Marks/ *Markah*)

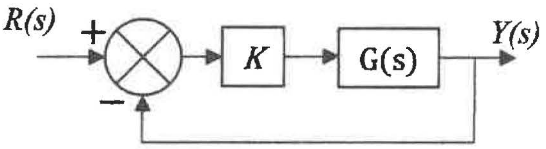


Figure 3
[Rajah 3]

Question 4
[Soalan 4]

A unity feedback system has a forward transfer function as shown in **Figure 4**. Design a PID controller by choosing the tuning parameters based on the Ziegler-Nichols closed loop technique. The rule-of-thumb for P, PI and PID controllers are given as in **Table 1** (in **Appendix 1**).

*[Satu sistem suap balik unit mempunyai satu rangkap pindah, ke depan seperti yang ditunjukkan dalam **Rajah 4**. Rekabentuk satu pengawal PID dengan memilih parameter-parameter talaan berdasarkan teknik gelung tertutup Ziegler-Nichols. Aturan-asas bagi pengawal P, PI dan PID diberikan seperti dalam **Jadual 1** (dalam **Lampiran 1**).]*

(25 Marks/ *Markah*)

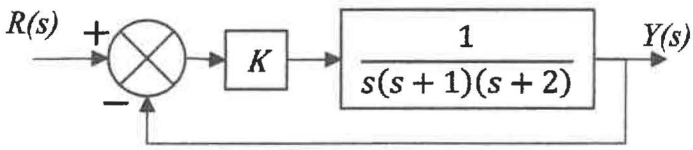


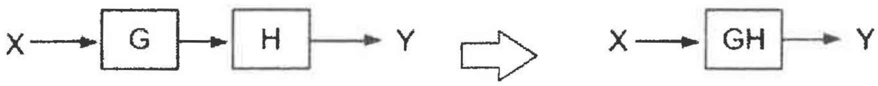
Figure 4
[Rajah 4]

Appendix 1
[Lampiran 1]

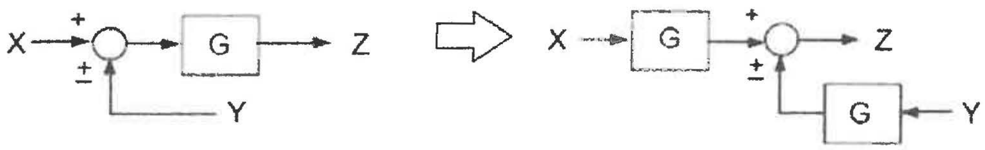
Table 1: Ziegler-Nichols Tuning
[Jadual 1: Talaan Ziegler-Nichols]

Controller	K_p	T_i	T_d
P	$0.5\ K_{cr}$	∞	0
PI	$0.45\ K_{cr}$	$0.833\ T$	0
PID	$0.6\ K_{cr}$	$0.5\ T$	$0.125\ T$

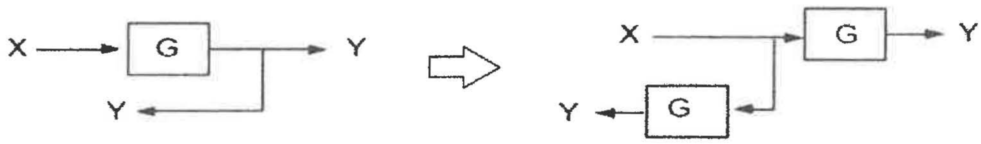
Cascaded blocks



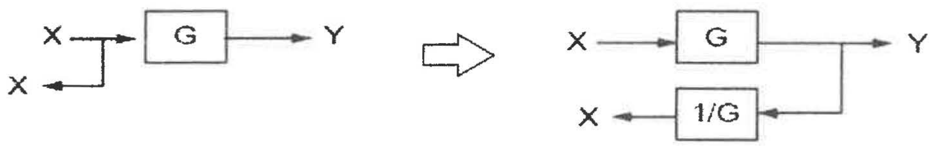
Moving a summer behind a block



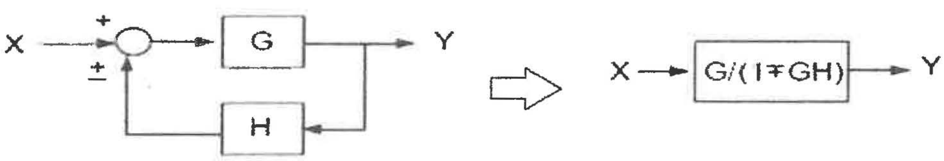
Moving a pickoff ahead of a block



Moving a pickoff behind a block



Eliminating a feedback loop



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General second order system

$$G(s) = \frac{Kb}{s^2 + as + b} = \frac{K\omega_n^{\,2}}{s^2 + 2\zeta\omega_n s + \omega_n^{\,2}}$$

Damping ratio, ζ

$$\zeta = \frac{a}{2\omega_n}$$

Natural frequency, ω_n

$$\omega_n = \sqrt{b}$$

Time peak, T_p

$$T_p = \frac{\pi}{\omega_n\sqrt{1-\zeta^2}} = \frac{\pi}{\omega_d}$$

Time settling, T_s

$$T_s \cong \frac{4}{\zeta\omega_n} = \frac{4}{\sigma_d}$$

Percent Overshoot, %OS

$$\%OS = e^{-\left(\frac{\zeta\pi}{\sqrt{1-\zeta^2}}\right)} \times 100$$

Damping ratio, ζ from Percent Overshoot, %OS

$$\zeta = \sqrt{\frac{ln\left(\frac{\%OS}{100}\right)^2}{\pi^2 + \left(\frac{\%OS}{100}\right)^2}}$$

Asymptote equations

$$\theta_a = \frac{r180^\circ}{n-m}$$

$$\sigma_a = \frac{\sum_{j=1}^{n} P_j - \sum_{i=1}^{m} Z_i}{n-m}$$

r =±1, ±3, ±5, ±7,.....

n= number of finite poles

m= number of finite zeros

Period of oscillation, T

$$T = \frac{2\pi}{\omega}$$

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