Ministry of Higher Education &
Scientific Research
Electrical Engineering Technical College
Department of Medical Instrumentation
Techniques Engineering

Subject: Control Theory.
Stage: 4th - stage
Date: 24 / 4 /2024
Time: One hour and a half...

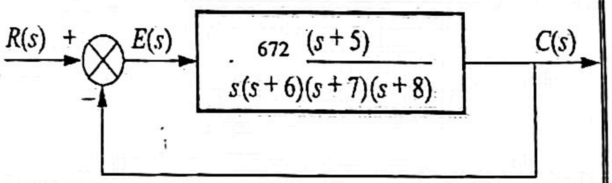
امتحان الفصل الثاني (المشترك)
2023/2024

Note: Answer All Questions

Q1	**The steady state error of due to unit step-input to a type 1 system is**		
A	$\frac{1}{1+K_p}$	**B**	**Zero**
C	$\frac{1}{K_p}$	**D**	∞
Q2	**The Routh criterion is used to determine**		
A	**Peak response of the system**	**B**	**Time response of the system**
C	**Absolute stability of the system**	**D**	**Roots of C.E. graphically**
Q3	**The system with the open loop transfer function 1/s(1+s) is:**		
A	**Type 2 and order 1**	**B**	**Type 1 and order 1**
C	**Type 0 and order 0**	**D**	**Type 1 and order 2**
Q4	**When the unit step response of a unity feedback control system having forward path transfer function G (s) =80/s(s+18) is called ……**		
A	**Overdamped system**	**B**	**Critically damped system**
C	**Under damped system**	**D**	**Un Damped oscillatory system**

Q5	**The initial response when the output is not equal to input is called :**		
A	**Transient response**	**B**	**Error response**
C	**Dynamic response**	**D**	**Either of the above**
Q6	**Transfer function of a system is used to calculate:**		
A	**Number of blocks**	**B**	**Peak overshoot**
C	**The output for any given input**	**D**	**Time domain**
Q7	**Consider the characteristic equation of a linear system, check how many roots in R.H.S of the equation using Routh stability test:** $2S^4+S^3+3S^2+5S+10=0$		
A	**Two**	**B**	**One**
C	**Three**	**D**	**Zero**

Q8	**Consider a closed loop second-order system with the transfer function $T(s) = \frac{4}{s^2+3s+4}$. Find the settling time for 2% tolerance**		
A	**0.24 sec.**	**B**	**0.75 sec.**
C	**4 sec.**	**D**	**2.67 sec.**

Q9	**Standard test signals in control system are:**		
A	**Impulse signal**	**B**	**Unit step signal**
C	**Ramp signal**	**D**	**All of the mentioned**
Q10	**The steady state error (ess(∞)) for unit ramp is:** 		
A	**10**	**B**	**0.2**
C	**20**	**D**	**0.1**
Q11	**By using Routh creteia the stability of C.E. $3S^5+5S^4+6S^3+3S+1=0$ is**		
A	**Stable**	**B**	**Marginally stable**
C	**Unstable**	**D**	**Absolut stable**
Q12	**If the poles of a system are lying on the imaginary axis in S-plane, the system will be**		
A	**stable**	**B**	**unstable**
C	**conditionally stable**	**D**	**marginally stable**

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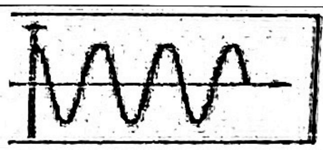
Q13	**The time required for the response to reach 50% of the final value in the first time is called the....**		
A	**Rise Time**	**B**	**Settling Time**
C	**Peak Time**	**D**	**delay time**
Q14	**The Damped Natural Frequency is**		
A	$W_n\sqrt{1-\zeta^2}$	**B**	**B.W**
C	t_p	**D**	ζ
Q15	**For the systems with the second order transfer functions, having damping ratio (ζ) equal 0.707 the angle β equal**		
A	$\beta = 0.25\,\pi$ **rad**	**B**	$\beta = 50°$
C	$\beta = \pi$ **rad**	**D**	$\beta = 60°$
Q16	**For the systems described by the following second order transfer functions, having damping ratio (ζ)=0.5, the value of gain (K) equal** $T.F = \frac{C(s)}{R(s)} = \frac{100}{S^2 + KS + 100}$		
A	**K=0.1**	**B**	**K=100**
C	**K=5**	**D**	**K=10**

Q17	**Determine K_P, K_V and K_a for the step, ramp, and parabolic error constants of the following G(s) with unity-feedback** $G(s) = \frac{K}{S(1+0.1S)(1+0.5S)}$		
A	$K_P = \infty$, $K_V = 10$, $K_a = 0$	**B**	$K_P = 0$, $K_V = 10$, $K_a = \infty$
C	$K_P = 1$, $K_V = k$, $K_a = 0$	**D**	$K_P = \infty$, $K_V = K$, $K_a = 0$
Q18	**If the response of a control system is was shown, then the system will be ....** 		
A	**Bounded input – bounded output**	**B**	**unbounded input – bounded output**
C	**Bounded input – unbounded output**	**D**	**Unbounded output**

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Q19	**Determine a rang of values of a system parameter K for which the system is stable:** $S^3 + 3S^2 + 3S + 1 + K = 0$		
A	$-4 < k < 8$	B	$-1 < k < 5$
C	$-1 < k < 8$	D	$-3 < k < 3$
Q20	**A method to find the stability without solving for the roots of the system is called …………**		
A	Root locus	B	Bode plot
C	Nyquist plot	D	Routh criteria

Q21	**The required by the response to reach from 10% to 90% of its final value is called:**		
A	delay time	B	settling time
C	settling time	D	Rising time
Q22	**The first column element of the Routh table is: [3, 5, -1, 0.5, 2] It means there**		
A	Two roots in the right half of s-plane	B	Three roots in the right half of s-plane
C	One roots in the right half of s-plane	D	Four roots in the right half of s-plane
Q23	**The maximum overshoot of** $36/(S^2 + 2S + 36)$		
A	0.587	B	0.44
C	0.1	D	1
Q24	**If the inputs to a control system are gradually changing function of time, then the best test signal will be**		
A	Step	B	Ramp
C	Impulse	D	Parabolic
Q25	**Consider a system with transfer function** $\frac{C(s)}{R(s)} = \frac{(s+6)}{ks^2+s+6}$ **The value of damping ratio (ζ) will be 0.5 when the value of k is**		
A	½	B	1/4
C	8	D	1/6

24/4/2024

حل الاسئلة (الامتحان المشترك)

Q1) من جدول steady state Erro اي نظام (Type=1) يعني موجود في المقام (s) معزول وكان الـ Unit step ← 1/p فأن $[e_{ss} = Zero]$ { اذا كنت حافظ الجدول } وبدون حفظه بعلاقة تحل بالشكل التالي

$$e_{ss} = \lim_{s \to 0} \frac{s \cdot R(s)}{1 + G(s)H(s)} = \frac{s \cdot 1/s}{1 + G(0)}$$

$$= \frac{1}{1 + \frac{1}{0(\cdots\cdots)}} = \frac{1}{1+\infty} = \phi$$

(B) الخيار

أو

$$K_p = \lim_{s \to 0} G(s)$$

$$= \lim_{s \to 0} \frac{1}{s(\cdots\cdots)} = \frac{1}{0} = \infty$$

(s ← Type 1 ، (⋯) ← اي معادلة)

$$e_{ss} = \frac{1}{1 + K_p} = \frac{1}{1+\infty} = \phi$$

Q2) Routh Criterion تستخدم لايجاد Absolute stability.

اي الخيار (D)

Q3) Open Loop T.F $= \dfrac{1}{s(1+s)} = \dfrac{1}{s^2+s}$

(2nd order, type = 1)

الحل هو (D)

لكن لو طلب الرتبه والصنف للـ Closed loop مثلاً with unity (−ve) feedback الحالة تتغير.

$$T(s) = \frac{G(s)}{1+G(s)} =$$

$$= \frac{1/s(s+1)}{1+\frac{1}{s(s+1)}} = \frac{1}{s(s+1)+1}$$

$$= \frac{1}{s^2+s+1}$$

و بذلك يكون

for closed loop → Order = 2, type = 0

هنا يجب إيجاد closed loop في هذا السؤال أي

Q4)

$$= \frac{G(s)}{1+G(s)} = \frac{80}{s(s+18)+80} = \frac{80}{s^2+18s+80}$$

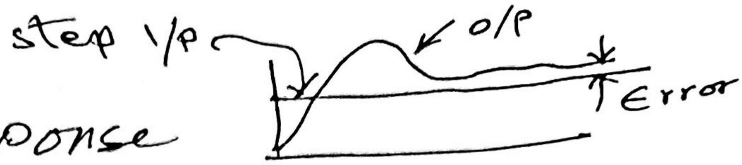
$$\sqrt{b^2-4ac} = \sqrt{(18)^2-4*1*80}$$

$$= \sqrt{324-320} = \sqrt{4} = 2$$

∴ الخيار **(A)** النظام Overdamped لأن تحت الجذر موجب

(3/10)

Q5) Error response



(B) الحل هو

Q6) Transfer Function is used to calculate output for any given input

$$T.F = \frac{Y(s)}{R(s)} \leftarrow \frac{o/p}{i/p}$$

(C) الحل هو

Q7) C/Cs Equation $2S^4 + S^3 + 3S^2 + 5S + 10 = 0$

من خلال (Routh Criterion) نفحص الاشارات في العمود الاول. فاذا كان هناك تغير بالاشارة مرة واحدة فحتما يوجد pole واحد في الجهة اليمنى R.H.S واذا كان هناك تغيرين بالاشارة فحتما Two poles

الحل هو

s^4	2	3	10
s^3	1	5	0
s^2	-7	10	
s^1	$\frac{-45}{-7}$		
s^0	10		

⟸

+	2
+	1
−	-7
+	$\frac{45}{7}$
+	10

تغير عدد (2) بالاشارة من موجب الى سالب ومن سالب الى موجب :

الحل هو 2 poles [تقع في الجهة اليمنى] اذا النظام Unstable

A

Q8) $T(s) = \frac{4}{s^2+3s+4} \Rightarrow \frac{\omega_n^2}{s^2+2\zeta\omega_n s+\omega_n^2}$

$\omega_n^2 = 4 \Longrightarrow \omega_n = 2$

$2\zeta\omega_n = 3 \Longrightarrow 2*\zeta*2 = 3 \Longrightarrow \zeta = \frac{3}{4}$

$t_s\Big|_{F2\%} = \frac{4}{\zeta\omega_n} = \frac{4}{\frac{3}{4_2}*2} = \frac{4}{1.5} = 2.67 \text{ sec}$

الحل هو (D)

Q9) ان الإشارات القياسية في فحص المنظومات هي جميع هذه الانواع المذكورة في السؤال.

الحل هو (D)

Q10) $e_{ss}(\infty)$ for Unit ramp $r(t)=t$

$R(s) = \frac{1}{s^2}$

$e_{ss} = \lim_{s\to 0} \frac{s\cdot R(s)}{1+G(s)} \quad \frac{\lim_{s\to 0} s\cdot\frac{1}{s^2}}{1+G(0)}$

$= \lim_{s\to 0} \frac{1/s}{1+\frac{672(s+5)}{s(s+6)(s+7)(s+8)}}$

$= \lim_{s\to 0} \frac{1}{s+s\left[\frac{672(s+5)}{s(s+6)(s+7)(s+8)}\right]} = \frac{1}{0+0}$

$= \frac{1}{672\times 5}$

(4/10)

$$e_{ss} = \frac{1}{\frac{672(5)}{6 \times 7 \times 8}} = \frac{1}{\frac{672 \times 5}{336}}$$

$$= \frac{1}{2 \times 5} = 0.1$$

الحل هو (D)

طريقة اخرى.

حسب K_v

$$K_v = \lim_{s \to 0} s \cdot G(s) =$$

$$= \lim_{s \to 0} s \cdot \frac{672(s+5)}{s(s+6)(s+7)(s+8)}$$

$$= \frac{672 \times 5}{336} = 10$$

$$e_{ss} = \frac{1}{K_v} = \frac{1}{10} = 0.1$$

يعني نفس النتيجة اعلاه

Q11) $3s^5 + 5s^4 + 6s^3 + 2s^2 + 3s + 1 = 0$

[3   5   6   −2   1/2   1]

s^5	3	6	3
s^4	5	0	1
s^3	6	$\frac{12}{5}$	0
s^2	$-\frac{12}{6}$	1	
s^1	$-\frac{24}{30}$ −6 −2		
s^0	1		

موجب

معناها يوجد تغير بالإشارة ⟸

النظام Unstable

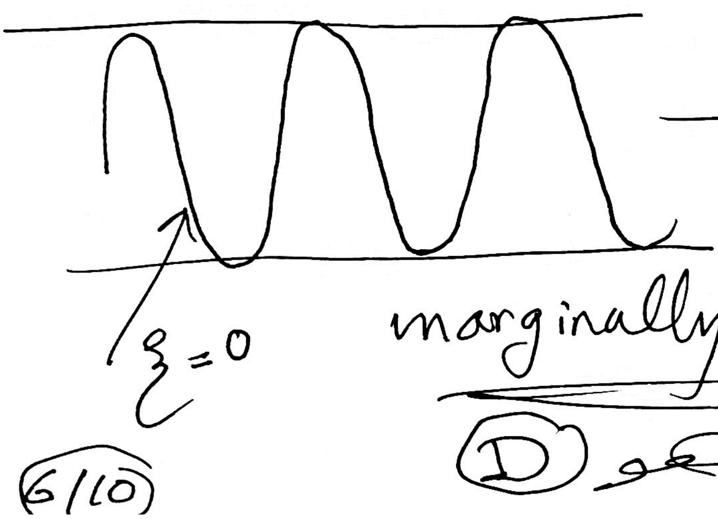
الحل هو (C)

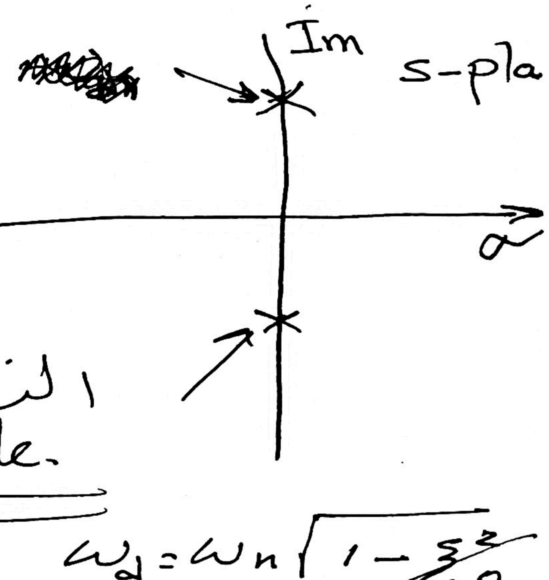
Q12) اذا وقعت poles على Imagenary axis

معناها لا يوجد جزء Real ← اي ان

النظام سيتصرف مثل اشارة ال Cosine

قمة ثابتة وذبذبة ثابتة (لا يوجد تخميد)





النظام marginally stable.

الحل هو (D)

$\omega_d = \omega_n\sqrt{1 - \xi^2}$

$\omega_d = \omega_n$

6/10

Q13)

الزمن لكي تصل الاستجابة الى 50%
من القيمة النهائية للـ (O/P) يمثل Delay time

الحل هو (D)

Q14) Damped Natural Frequency

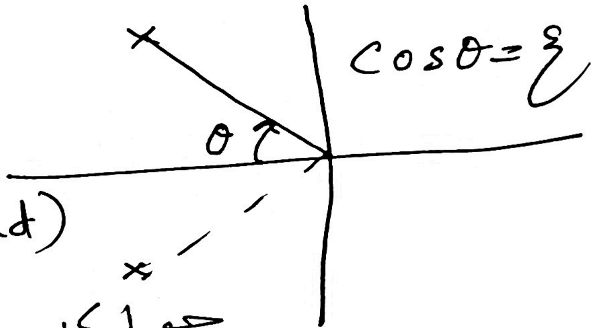
$$\omega_d = \omega_n \sqrt{1-\xi^2}$$

∴ الحل هو (A)

Q15) اذا كانت $\xi = 0.707$ فإن الزاوية

$$\therefore \theta = \beta = \cos^{-1} 0.707$$

$$= \frac{\pi}{4} = 0.25\pi \text{ (rad)}$$



حول النسبة بالـ Radian

الحل هو (A)

Q16) $T.F = \frac{C(s)}{R(s)} = \frac{100}{s^2 + Ks + 100}$

هنا $100 = \omega_n^2 \Rightarrow \omega_n = 10$

$\xi = 0.5, \omega_n = 10 \Rightarrow 2\xi\omega_n = K$

$K = 2 * 0.5 * 10 = 10$

الحل هو (D)

(7/10)

Q17)

$$K_p = \lim_{s \to 0} G(s) = \lim_{s \to 0} \frac{K}{s(1+0.1s)(1+0.5s)}$$

$$= \frac{K}{0} = \infty$$

$$K_v = \lim_{s \to 0} s.G(s) = \lim_{s \to 0} \frac{s.K}{s(1+0.1s)(1+0.5s)}$$

$$= \lim_{s \to 0} \frac{K}{(0.1)(0.5)[(10+s)(2+s)]}$$

$$= \lim_{s \to 0} \frac{10 * 2 * K}{(10+s)(2+s)} = \frac{20K}{20}$$

$$= K$$

$$K_a = \lim_{s \to 0} s^2.G(s) = \frac{s^2.K \times 20}{s(s+10)(s+2)} = 0$$

∴ $\left[\overset{K_p}{\infty}, \overset{K_v}{K}, \overset{K_a}{0}\right]$ (D) الحل هو

Q18) Bounded input - Bounded output

(A) الخيار هو

Q20) Response 10-90% of its final is called Rise time

(D) الخيار هو

(8/10)

Q19) لايجاد قيمة K التي تجعل النظام مستقر هي القيمة التي تجعل العمود الاول للـ Routh table ليس فيه اي تغير في الاشارات .

s^3	1	3
s^2	3	$(1+K)$
s^1	$\frac{9-1-K}{3}$	0
s^0	$1+K$	

$1+K=0$ —— ①

$\therefore K>-1$

$9-1-K=8-K$ —— ②

$\therefore K<8$

$(-1<K<8)$

∴ الحل هو اختيار (C)

Q20) A method to find stability بدون حل معادلة c/cs وايجاد الجذور تكون باستخدام جدول راوث

Routh table

∴ الحل هو (D)

Q22) First Column of Routh table هو $[\overset{+}{3}, \overset{+}{5}, \overset{-}{-1}, \overset{+}{0.5}, \overset{+}{2}]$ اي هناك تغير بالاشارة عدد/2 اي Two roots in R.H.S

الحل هو (A)

9/10

Q23) $M_p = e^{-\pi\xi/\sqrt{1-\xi^2}}$ (10/10)

$$\frac{\omega_n^2}{s^2+2\xi\omega_n s+\omega_n^2}$$

$$\frac{C(s)}{R(s)} = \frac{36}{s^2+2s+36}$$

$\omega_n^2 = 36 \Rightarrow \omega_n = 6$

$2\xi\omega_n = 2 \Rightarrow 2\times\xi\times 6 = 2 \Rightarrow \xi = \frac{1}{6}$

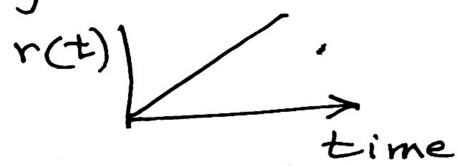
$\xi = \frac{1}{6} = 0.167$

$M_p = e^{-\pi * 0.167/\sqrt{1-(.167)^2}}$

$= 0.587$ الحل هو (A)

Q24) Ramp is changing with time

(B) الحل هو :



Q25) لحل هذا النظام يجب ان نجعل معامل s^2 واحد
أي نقسم على K فيصبح الشكل الاخر للمعادلة

$$\frac{C(s)}{R(s)} = \frac{(s+6)}{K(s^2 + \frac{1}{K}s + \frac{6}{K})}$$

$\frac{6}{K} = \omega_n^2$ —— (1) $\omega_n = \sqrt{\frac{6}{K}}$

$\frac{1}{K} = 2\xi\omega_n$ ($\xi = 0.5$) $\frac{1}{K} = 2\times 0.5\sqrt{\frac{6}{K}}$

بتربيع الطرفين

$\boxed{K = 6K^2 \Rightarrow K = \frac{1}{6}}$ $\frac{1}{K^2} = \frac{6}{K}$

الحل هو (D)