Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2018/2019

COURSE NAME	:	POWER PLANT INSTRUMENTATION & CONTROL
COURSE CODE	:	BNE 32503
PROGRAMME CODE	:	BNE
EXAMINATION DATE	:	DECEMBER 2018 / JANUARY 2019
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

TERBUKA

THIS QUESTION PAPER CONSISTS OF **TWELVE (12)** PAGES

Q1 (a) Give **TWO (2)** advantages of closed-loop system.

(2 marks)

(b) Draw the graph of the system response for antenna azimuth closed-loop system with low gain and high gain configuration.

(3 marks)

(c) Find the Laplace transform, $F(s)$ for $f(t)=te^{-6t}$.

(6 marks)

(d) Prove that the Laplace transform for $f(t) = e^{-at}\sin\omega t$ is equal to $F(s) = \frac{s+a}{(s+a)^2+\omega^2}$

(9 marks)

Q2 (a) Find the transfer function, $\frac{Y(s)}{X(s)}$ for $1800(\dot{y} - \dot{x}) + 130(y - x) - 100(\ddot{y}) = 20\ddot{x}$.

(3 marks)

(b) Differentiate between critically damped, overdamped and undamped condition.

(3 marks)

(c) Based on the s-plane poles and zero location of a unity closed-loop system shown in **Figure Q2(b),**

(i) determine the transfer function, $T(s)$ or $\frac{C(s)}{R(s)}$ of the closed-loop system.

(4 marks)

(ii) find the damping ratio, ζ and natural frequency ω_n of the system.

(2 marks)

(iii) name and plot the step response of this system.

(1 marks)

(iv) determine the response of the system if the poles moves to (-3+3i and -3-3i).

(1 mark)

(d) A unity feedback system has the following forward transfer function;

$$G(s) = \frac{K(s+2)(s+4)(s+5)(s+6)(s+7)}{s^2(s+8)(s+10)(s+12)}$$

Find the value of K to yield a 0.114 % error in the steady state.

(5 marks)

Q3 (a) Determine whether any of the roots of the following transfer function are in the right half plane by using reverse coefficient method.

$$T(s) = \frac{9}{s^5 + 3s^4 + 2s^3 + 6s^2 + 6s + 9}$$

(4 marks)

(b) For the power plant system shown in **Figure Q3(b)**, use the Routh-Hurwitz Criterion to identify the location of close-loop poles that lie in the left-half-plane, in the right-half plane, and on the imaginary axis. Notice that there is positive feedback.

(10 marks)

(c) For the unity feedback system shown in **Figure Q3(c)**, where

$$G(s) = \frac{K}{(s+1)^3(s+4)}$$

Find the range of K for stability.

(6 marks)

Q4 (a) **Figure Q4(a)** shows a piping and instrumentation drawing (P&ID) for a section of process control system in the power plant. List the instruments below from the P&ID diagram.

(i) FC220

(ii) FV/220

(iii)LT/220

(iv)LC/220

(4 marks)

(b) For measurement systems or control systems, part of the specification is the range of the variables involved. Two analog standards are in common use as a means of representing the range of variables in control systems. The most common current transmission signal is 4 to 20 mA. Suppose the temperature range is set to 20°C to 120°C and it is linearly converted to the standard current range of 4 to 20 mA.

(i) Calculate the current value when the temperature is 66°C.
(2 marks)

(ii) Calculate the temperature value when the current value is 6.5 mA.
(2 marks)

(c) A type J thermocouple with a reference is used to measure the oven temperature from 300° to 400°C. Calculate the output voltages correspond to these temperatures. Type J thermocouple reference tables is provided in **Table Q4(c)**.
(5 marks)

(d) A digital multimeter measures the current through a 12.5 $k\Omega$ resistor as 2.21 mA, using the 10 mA scale. The instrument accuracy is $\pm 0.2\%\ FS$.

(i) Identify the voltage across the resistor and the uncertainty in the value obtained.
(5 marks)

(ii) Explain why uncertainty must be introduced for the voltage value obtained in **Q4(d)(i)**.
(2 marks)

Q5 (a) The topology of a network is the geometric representation of the relationship of all the links and linking devices (usually called nodes) to one another. State **FOUR (4)** possible basic topologies and illustrates the diagram of the **TWO (2)** topologies given.
(6 marks)

(b) In **Figure Q5(b)**, computer *sender* sends a message to computer *receiver* via LAN, router 1 and router 2. List out the contents of the packets at the network for each hop interfaces from **A** to **H**.
(6 marks)

(c) A non-periodic composite signal contains frequencies from 10 to 30 KHz. The peak amplitude is 10 V for the lowest and the highest signals and is 30 V for the 20 kHz signal. Assuming that the amplitudes change gradually from the minimum to the maximum.

(i) Draw the frequency spectrum

(3 marks)

(ii) Calculate the bandwidth of the signal

(1 mark)

(iii) If the network with the bandwidth of 20 Mbps send 15,000 frames per 2 minutes with the throughput that is one-fifth of the bandwidth in this case, compute average number of bits for each frame.

(4 marks)

- END OF QUESTIONS –

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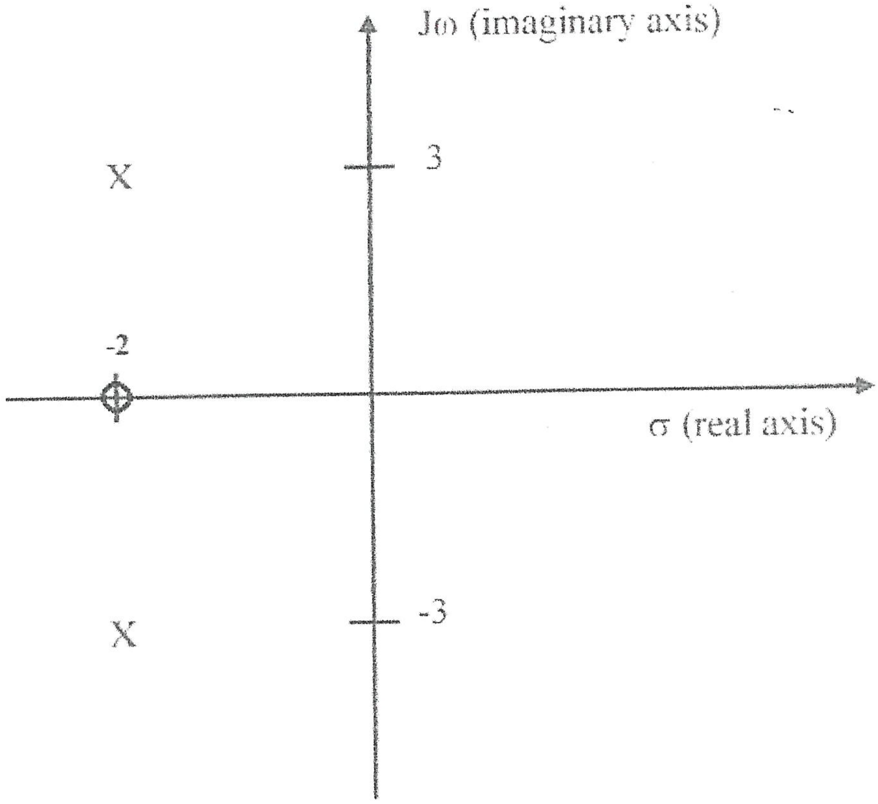

Figure Q1(b)

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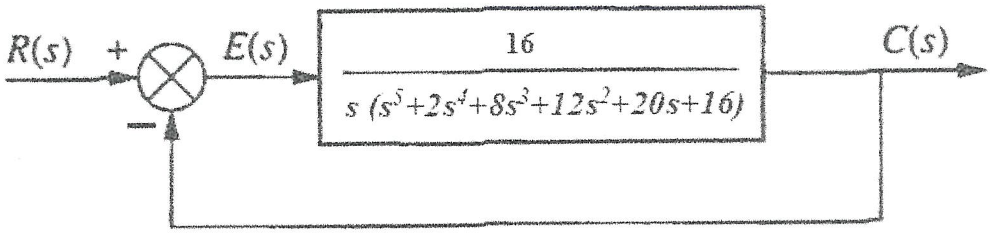

Figure Q3(b)

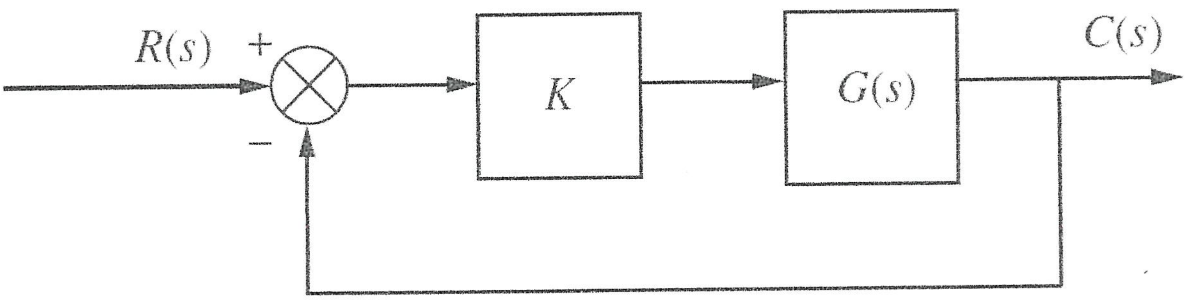

Figure Q3(c)

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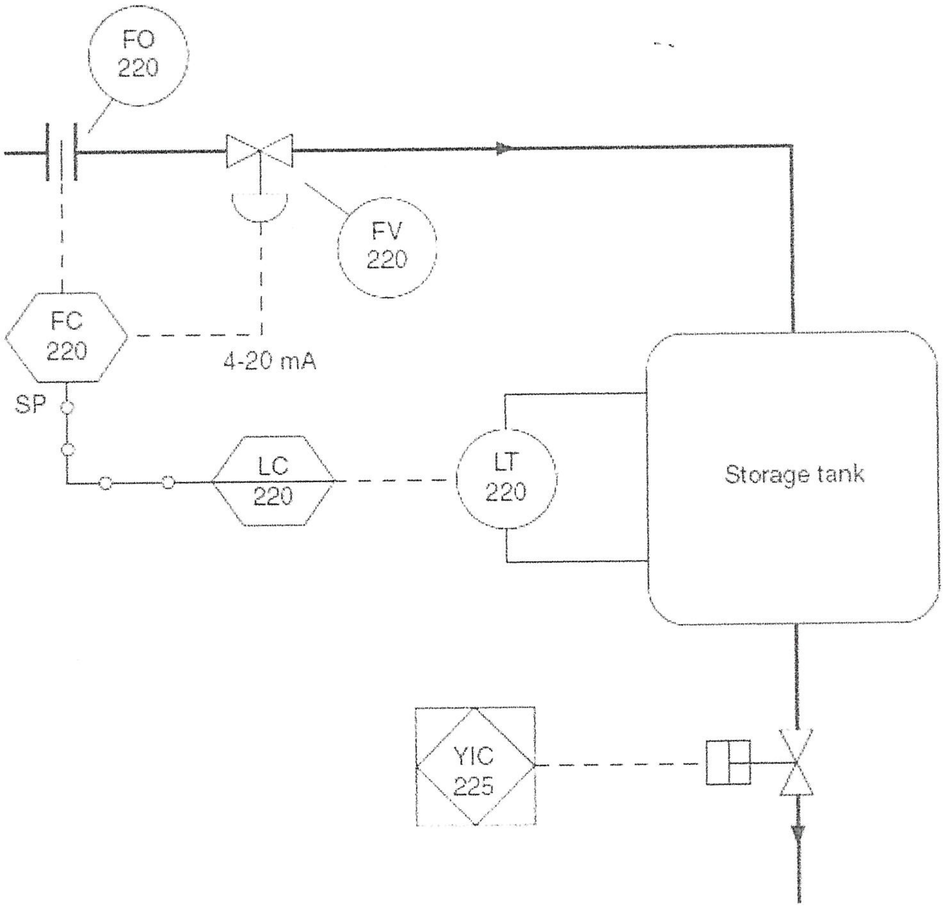

Figure Q4(a)

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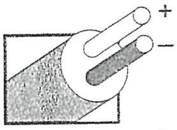
Table Q4(c)

Revised Thermocouple Reference Tables

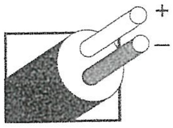
TYPE J

Reference Tables N.I.S.T. Monograph 175 Revised to ITS-90



Thermocouple Grade

Iron vs. Copper-Nickel



Extension Grade

MAXIMUM TEMPERATURE RANGE

Thermocouple Grade
32 to 1382°F
0 to 750°C

Extension Grade
32 to 392°F
0 to 200°C

LIMITS OF ERROR
(whichever is greater)
Standard: 2.2°C or 0.75%
Special: 1.1°C or 0.4%

COMMENTS, BARE WIRE ENVIRONMENT:
Reducing, Vacuum, Inert; Limited Use in Oxidizing at High Temperatures; Not Recommended for Low Temperatures

TEMPERATURE IN DEGREES °C
REFERENCE JUNCTION AT 0°C

Thermoelectric Voltage in Millivolts

°C	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	°C
-200	-8.095	-8.076	-8.057	-8.037	-8.017	-7.996	-7.976	-7.955	-7.934	-7.912	-7.890	-200
-190	-7.890	-7.868	-7.846	-7.824	-7.801	-7.778	-7.755	-7.731	-7.707	-7.683	-7.659	-190
-180	-7.659	-7.634	-7.610	-7.585	-7.559	-7.534	-7.508	-7.482	-7.456	-7.429	-7.403	-180
-170	-7.403	-7.376	-7.348	-7.321	-7.293	-7.265	-7.237	-7.209	-7.181	-7.152	-7.123	-170
-160	-7.123	-7.094	-7.064	-7.035	-7.005	-6.975	-6.944	-6.914	-6.883	-6.853	-6.821	-160
-150	-6.821	-6.790	-6.759	-6.727	-6.695	-6.663	-6.631	-6.598	-6.566	-6.533	-6.500	-150
-140	-6.500	-6.467	-6.433	-6.400	-6.366	-6.332	-6.298	-6.263	-6.229	-6.194	-6.159	-140
-130	-6.159	-6.124	-6.089	-6.054	-6.018	-5.982	-5.946	-5.910	-5.874	-5.838	-5.801	-130
-120	-5.801	-5.764	-5.727	-5.690	-5.653	-5.616	-5.578	-5.541	-5.503	-5.465	-5.426	-120
-110	-5.426	-5.388	-5.350	-5.311	-5.272	-5.233	-5.194	-5.155	-5.116	-5.076	-5.037	-110
-100	-5.037	-4.997	-4.957	-4.917	-4.877	-4.836	-4.796	-4.755	-4.714	-4.674	-4.633	-100
-90	-4.633	-4.591	-4.550	-4.509	-4.467	-4.425	-4.384	-4.342	-4.300	-4.257	-4.215	-90
-80	-4.215	-4.173	-4.130	-4.088	-4.045	-4.002	-3.959	-3.916	-3.872	-3.829	-3.786	-80
-70	-3.786	-3.742	-3.698	-3.654	-3.610	-3.566	-3.522	-3.478	-3.434	-3.389	-3.344	-70
-60	-3.344	-3.300	-3.255	-3.210	-3.165	-3.120	-3.075	-3.029	-2.984	-2.938	-2.893	-60
-50	-2.893	-2.847	-2.801	-2.755	-2.709	-2.663	-2.617	-2.571	-2.524	-2.478	-2.431	-50
-40	-2.431	-2.385	-2.338	-2.291	-2.244	-2.197	-2.150	-2.103	-2.055	-2.008	-1.961	-40
-30	-1.961	-1.913	-1.865	-1.818	-1.770	-1.722	-1.674	-1.626	-1.578	-1.530	-1.482	-30
-20	-1.482	-1.433	-1.385	-1.336	-1.288	-1.239	-1.190	-1.142	-1.093	-1.044	-0.995	-20
-10	-0.995	-0.946	-0.896	-0.847	-0.798	-0.749	-0.699	-0.650	-0.600	-0.550	-0.501	-10
0	-0.501	-0.451	-0.401	-0.351	-0.301	-0.251	-0.201	-0.151	-0.101	-0.050	0.000	0

°C	0	1	2	3	4	5	6	7	8	9	10	°C
0	0.000	0.050	0.101	0.151	0.202	0.253	0.303	0.354	0.405	0.456	0.507	0
10	0.507	0.558	0.609	0.660	0.711	0.762	0.814	0.865	0.916	0.968	1.019	10
20	1.019	1.071	1.122	1.174	1.226	1.277	1.329	1.381	1.433	1.485	1.537	20
30	1.537	1.589	1.641	1 693	1.745	1.797	1.849	1.902	1.954	2.006	2.059	30
40	2.059	2 111	2.164	2.216	2.269	2.322	2.374	2.427	2.480	2.532	2.585	40
50	2.585	2.638	2.691	2.744	2.797	2.850	2.903	2.956	3.009	3.062	3.116	50
60	3.116	3.169	3.222	3.275	3.329	3.382	3.436	3.489	3.543	3.596	3.650	60
70	3.650	3.703	3.757	3.810	3.864	3.918	3.971	4.025	4.079	4.133	4.187	70
80	4.187	4.240	4.294	4.348	4.402	4.456	4.510	4.564	4.618	4.672	4.726	80
90	4.726	4.781	4.835	4.889	4.943	4.997	5.052	5.106	5.160	5.215	5.269	90
100	5.269	5.323	5.378	5.432	5.487	5.541	5.595	5.650	5.705	5.759	5 814	100
110	5.814	5.868	5.923	5.977	6.032	6.087	6.141	6.196	6.251	6.306	6.360	110
120	6.360	6.415	6.470	6.525	6.579	6.634	6.689	6.744	6.799	6.854	6.909	120
130	6.909	6.964	7.019	7.074	7.129	7.184	7.239	7.294	7.349	7.404	7.459	130
140	7.459	7.514	7.569	7.624	7.679	7.734	7.789	7.844	7.900	7.955	8.010	140
150	8.010	8.065	8.120	8.175	8.231	8.286	8.341	8.396	8.452	8.507	8.562	150
160	8.562	8.618	8.673	8.728	8.783	8.839	8.894	8.949	9.005	9.060	9.115	160
170	9.115	9.171	9.226	9.282	9.337	9.392	9.448	9.503	9.559	9.614	9.669	170
180	9.669	9.725	9.780	9.836	9.891	9.947	10.002	10.057	10.113	10.168	10.224	180
190	10.224	10.279	10.335	10.390	10.446	10.501	10.557	10.612	10.668	10.723	10.779	190
200	10.779	10.834	10.890	10.945	11.001	11.056	11.112	11.167	11.223	11.278	11.334	200
210	11.334	11.389	11.445	11.501	11.556	11.612	11.667	11.723	11.778	11.834	11.889	210
220	11.889	11.945	12.000	12.056	12.111	12.167	12.222	12.278	12.334	12.389	12.445	220
230	12.445	12.500	12.556	12.611	12.667	12.722	12.778	12.833	12.889	12.944	13.000	230
240	13.000	13.056	13.111	13.167	13.222	13.278	13.333	13.389	13.444	13.500	13.555	240
°C	0	1	2	3	4	5	6	7	8	9	10	°C

°C	0	1	2	3	4	5	6	7	8	9	10	°C
250	13.555	13.611	13.666	13.722	13.777	13.833	13.888	13.944	13.999	14.055	14.110	250
260	14.110	14.166	14.221	14.277	14.332	14.388	14.443	14.499	14.554	14.609	14.665	260
270	14.665	14.720	14.776	14.831	14.887	14.942	14.998	15.053	15.109	15.164	15.219	270
280	15.219	15.275	15.330	15.386	15.441	15.496	15.552	15.607	15.663	15.718	15.773	280
290	15.773	15.829	15.884	15.940	15.995	16.050	16.106	16.161	16.216	16.272	16.327	290
300	16.327	16.383	16.438	16.493	16.549	16.604	16.659	16.715	16.770	16.825	16.881	300
310	16.881	16.936	16.991	17.046	17.102	17.157	17.212	17.268	17.323	17.378	17.434	310
320	17.434	17.489	17.544	17.599	17.655	17.710	17.765	17.820	17.876	17.931	17.986	320
330	17.986	18.041	18.097	18.152	18.207	18.262	18.318	18.373	18.428	18.483	18.538	330
340	18.538	18.594	18.649	18.704	18.759	18.814	18.870	18.925	18.980	19.035	19.090	340
350	19.090	19.146	19.201	19.256	19.311	19.366	19.422	19.477	19.532	19.587	19.642	350
360	19.642	19.697	19.753	19.808	19.863	19.918	19.973	20.028	20.083	20.139	20.194	360
370	20.194	20.249	20.304	20.359	20.414	20.469	20.525	20.580	20.635	20.690	20.745	370
380	20.745	20.800	20.855	20.911	20.966	21.021	21.076	21.131	21.186	21.241	21.297	380
390	21.297	21.352	21.407	21.462	21.517	21.572	21.627	21.683	21.738	21.793	21.848	390
400	21.848	21.903	21.958	22.014	22.069	22.124	22.179	22.234	22.289	22.345	22.400	400
410	22.400	22.455	22.510	22.565	22.620	22.676	22.731	22.786	22.841	22.896	22.952	410
420	22.952	23.007	23.062	23.117	23.172	23.228	23.283	23.338	23.393	23.449	23.504	420
430	23.504	23.559	23.614	23.670	23.725	23.780	23.835	23.891	23.946	24.001	24.057	430
440	24.057	24.112	24.167	24.223	24.278	24.333	24.389	24.444	24.499	24.555	24.610	440
450	24.610	24.665	24.721	24.776	24.832	24.887	24.943	24.998	25.053	25.109	25.164	450
460	25.164	25.220	25.275	25.331	25.386	25.442	25.497	25.553	25.608	25.664	25.720	460
470	25.720	25.775	25.831	25.886	25.942	25.998	26.053	26.109	26.165	26.220	26.276	470
480	26.276	26.332	26.387	26.443	26.499	26.555	26.610	26.666	26.722	26.778	26.834	480
490	26.834	26.889	26.945	27.001	27.057	27.113	27.169	27.225	27.281	27.337	27.393	490
°C	0	1	2	3	4	5	6	7	8	9	10	°C

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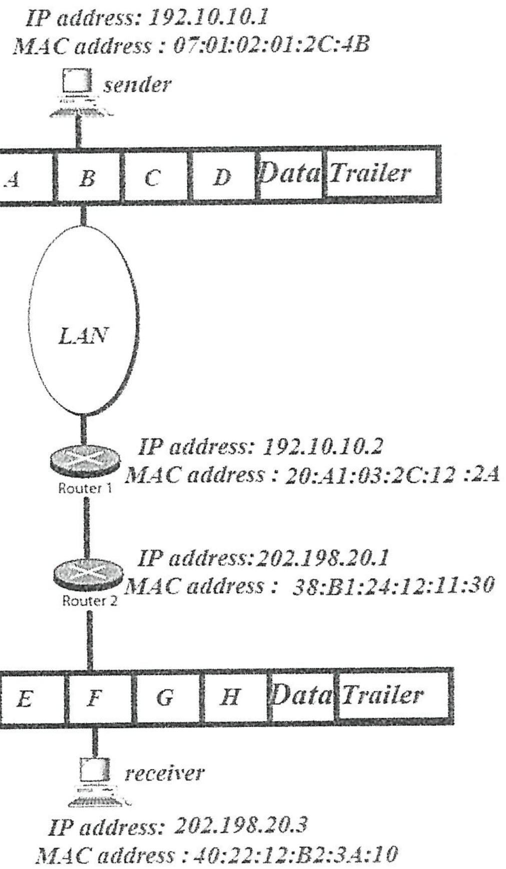

Figure Q5(b)

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APPENDIX

Table A1

Input	Steady-state error formula	Type 0 Static error constant	Type 0 Error	Type 1 Static error constant	Type 1 Error	Type 2 Static error constant	Type 2 Error
Step, $u(t)$	$\frac{1}{1+K_p}$	$K_p=$ Constant	$\frac{1}{1+K_p}$	$K_p=\infty$	0	$K_p=\infty$	0
Ramp, $tu(t)$	$\frac{1}{K_v}$	$K_v=0$	∞	$K_v=$ Constant	$\frac{1}{K_v}$	$K_v=\infty$	0
Parabola, $\frac{1}{2}t^2u(t)$	$\frac{1}{K_a}$	$K_a=0$	∞	$K_a=0$	∞	$K_a=$ Constant	$\frac{1}{K_a}$

Table A2: Laplace Transform Table

$f(t)$	$F(s)$
$\delta(t)$	1
$u(t)$	$\frac{1}{s}$
$tu(t)$	$\frac{1}{s^2}$
$t^n u(t)$	$\frac{n!}{s^{n+1}}$
$e^{-at}u(t)$	$\frac{1}{s+a}$
$\sin\omega t u(t)$	$\frac{\omega}{s^2+\omega^2}$
$\cos\omega t u(t)$	$\frac{s}{s^2+\omega^2}$
$e^{-at}\sin\omega t u(t)$	$\frac{\omega}{(s+a)^2+\omega^2}$
$e^{-at}\cos\omega t u(t)$	$\frac{(s+a)}{(s+a)^2+\omega^2}$

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Table B: Laplace Transform Theorem

Name	Theorem
Frequency shift	$\mathcal{L}\left[e^{-at} f(t)\right] = F(s+a)$
Time shift	$\mathcal{L}\left[f(t-T)\right] = e^{-sT} F(s)$
Differentiation	$\mathcal{L}\left[\frac{d^n f}{dt^n}\right] = s^n F(s) - \sum_{k=1}^{n} s^{n-k} f^{k-1}(0^-)$
Integration	$\mathcal{L}\left[\int_{0^-}^{t} f(\tau) d\tau\right] = \frac{F(s)}{s}$
Initial value	$\lim_{t \to 0} f(t) = \lim_{s \to \infty} sF(s)$
Final value	$\lim_{t \to \infty} f(t) = \lim_{s \to 0} sF(s)$

Table C: 2nd Order prototype System equations

$\frac{C(s)}{R(s)} = \frac{\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2}$	$T_r = \frac{\pi - \cos^{-1}\zeta}{\omega_n\sqrt{1-\zeta^2}}$
$\mu_p = e^{\frac{-\zeta\pi}{\sqrt{1-\zeta^2}}}$	$T_p = \frac{\pi}{\omega_n\sqrt{1-\zeta^2}}$
$T_s = \frac{4}{\zeta\omega_n}$	