

0. Fill in circle 1 under GRADE OR EDUCATION on side two of your answer sheet (and fill in your name, person number).

- The slope of the static calibration curve is known as the:
 - Response function
 - Time constant
 - Static sensitivity
 - Instrument bias
- A discrete digital representation of a signal can be made more precise than the original input signal.
 - True
 - False
- If a ADC device has a full scale voltage range of 10 volts, a gain of 1.0 and a word length of 12 bits, what is its resolution?
 - 0.000244
 - 4.88×10^{-3}
 - 0.000488
 - 2.44×10^{-3}
 - none of the above
- Quantization refers to
 - the fact that A/D conversion process requires a finite amount of time.
 - the fact that the number representing an analog signal has a finite precision.
 - the fact that the precision of an ADC is determined by its word length
 - (b) and (c) are correct
- The slowest sampling frequency that would avoid aliasing the wave form $y(t) = 15 \sin(25\omega t) + 8 \cos(5\omega t)$ is:
 - 12.5 samples/sec
 - 25 samples/sec
 - 10 samples/sec
 - 12.5π samples/sec
- In Lab2, "Thermocouple Static and Dynamic Calibration", the thermocouple is modeled as a first-order system.
$$\tau \frac{dT}{dt} + T(t) = Kx(t)$$
The transfer function of this system is given by:
 - $G(s) = K/s$
 - $G(s) = K e^{-s\tau} / s$
 - $G(s) = K/(\tau s + 1)$
 - $G(s) = K/(\tau s + 1) s$
- The above mathematical model of a thermocouple is derived from:
 - conservation of energy
 - linear circuit equations
 - conservation of electrical charge

8. In Lab 3, "Conversion of Work into Heat", the dominant mechanism for heat loss during the calorimeter cool down phase of the experiment was:
- conduction to the calorimeter support
 - convection to the atmosphere
 - radiation to the surround environment

9. A first-order linear system is described by the following differential equation and initial condition:

$$\begin{array}{ll} \text{ODE} & \tau \frac{dT}{dt} + T(t) = Kx(t) \\ \text{IC} & T(0) = T_0 \end{array}$$

The correct solution is

- $T(t) = T_0 e^{-(t/\tau)} + K(1 - e^{-(t/\tau)})$
 - $T(t) = K(1 - e^{-(t/\tau)})$
 - $T(t) = T_0 e^{-(t/\tau)} - K e^{-(t/\tau)}$
10. If the input signal, $x(t)$ is voltage and the output signal, $T(t)$, is temperature, what are the units of the static sensitivity, K ?
- volts
 - Celsius
 - Celsius/volt
 - seconds
11. If the time constant equals 4.0 seconds, how long does it take for the initial condition response to decrease to 0.1% of its initial value T_0 ?
- 18.0 sec
 - 24.0 sec
 - 28.0 sec
 - 50.0 sec
12. The frequency response for a first-order system is given by the magnitude ratio

$$M(\omega) = 1.0 / [1 + (4\omega)^2]^{1/2}$$

and the phase angle

$$\Phi(\omega) = -\tan^{-1}(4\omega)$$

If the frequency of the input signal is 10 hertz and the amplitude is 1.0 mv, what is the amplitude of the output signal?

- 1.0 mv
 - 0.004 mv
 - 0.025 mv
13. What is the phase angle of the output signal?
- 88.6 deg
 - 90.0 deg
 - 89.8 deg
 - 0.0 deg

14. If the input signal has a frequency of 10 hertz, what is the frequency of the output signal?
- 62.83 rad/sec
 - 6.283 rad/sec
 - 0.6283 rad/sec
 - 0.0 rad/sec
15. The dynamic response of a second-order system to a step input is determined by the roots of its characteristic equation. If the system has the following characteristic equation
- $$s^2 + 6s + 25 = 0$$
- what the characteristic roots
- ~~-3/7 and 3/7~~
 - ~~-3/7 + 4j and -3/7 - 4j~~
 - ~~-4j and 4j~~
 - ~~3/7 + 4j and 3/7 - 4j~~
16. The wave form of the output signal is a:
- sinusoid
 - exponential
 - damped sinusoid
 - none of the above
17. The natural frequency of this system is:
- 5 rad/sec
 - 31.4 rad/sec
 - 25.0 hertz
18. The damping ratio for this system is:
- 6.0
 - 0.6
 - 0.3
19. Table 4.3 gives Probability Values for the Normal Error Function. A random variable X has a normal distribution with mean zero and standard deviation 1. Using the table, determine the probability that a realization of X falls outside the 1 sigma bounds; i.e. $P\{|X| > 1.0\}$
- 0.3413
 - 0.6826
 - 0.6567
 - 0.3174
20. The sample variance in the strength values of 50 bricks is $6.89 \text{ (mN/m}^2\text{)}^2$, with a sample mean of 6.92 mN/m^2 . What is the precision error, PE, of the sample mean at a 95% confidence level?
- PE = +/- 0.371

- b. PE = +/- 0.728
c. PE = +/- 0.975
d. None of the above
21. The precision error of the estimate of the true mean in question 20 can be improved by
- increasing the sensitivity of the measurement device
 - improving the precision of the measurement device
 - increasing the total number of measurement
 - (b) and (c)
22. The following data were collected during the repeated measurement of the force load acting on a small area of a beam under "fixed" conditions.
- | Number | Output (N) |
|--------|------------|
| 1. | 923 |
| 2. | 932 |
| 3. | 908 |
| 4. | 919 |
- The sample mean is:
- 923
 - 920.5
 - 921.3
 - None of the above
23. Calculate the sample standard deviation. The sample standard deviation is:
- 8.62
 - 17.25
 - 9.95
 - None of the above
24. Determine the confidence interval for the sample mean at 90% probability.
- (910.8, 930.3)
 - (910.6, 930.5)
 - (908.8, 932.2)
 - None of the above
25. The 90% confidence interval on the sample mean in question 24 means that
- there is a 90% probability that the true mean of the force load lies in this interval
 - the true mean cannot lie outside this interval
 - if 10 new measurements are taken, 9 out of 10 will lie this interval
 - (a) and (c)

Table 4.3 Probability Values for Normal Error Function

One-Sided Integral Solutions for $p(z_1) = \frac{1}{(2\pi)^{1/2}} \int_0^{z_1} e^{-\beta^2/2} d\beta$

$z_1 = \frac{x_1 - x'}{\sigma}$	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.0000	0.0040	0.0080	0.0120	0.0160	0.0199	0.0239	0.0279	0.0319	0.0359
0.1	0.0398	0.0438	0.0478	0.0517	0.0557	0.0596	0.0636	0.0675	0.0714	0.0753
0.2	0.0793	0.0832	0.0871	0.0910	0.0948	0.0987	0.1026	0.1064	0.1103	0.1141
0.3	0.1179	0.1217	0.1255	0.1293	0.1331	0.1368	0.1406	0.1443	0.1480	0.1517
0.4	0.1554	0.1591	0.1628	0.1664	0.1700	0.1736	0.1772	0.1808	0.1844	0.1879
0.5	0.1915	0.1950	0.1985	0.2019	0.2054	0.2088	0.2123	0.2157	0.2190	0.2224
0.6	0.2257	0.2291	0.2324	0.2357	0.2389	0.2422	0.2454	0.2486	0.2517	0.2549
0.7	0.2580	0.2611	0.2642	0.2673	0.2704	0.2734	0.2764	0.2794	0.2823	0.2852
0.8	0.2881	0.2910	0.2939	0.2967	0.2995	0.3023	0.3051	0.3078	0.3106	0.3133
0.9	0.3159	0.3186	0.3212	0.3238	0.3264	0.3289	0.3315	0.3340	0.3365	0.3389
1.0	0.3413	0.3438	0.3461	0.3485	0.3508	0.3531	0.3554	0.3577	0.3599	0.3621
1.1	0.3643	0.3665	0.3686	0.3708	0.3729	0.3749	0.3770	0.3790	0.3810	0.3830
1.2	0.3849	0.3869	0.3888	0.3907	0.3925	0.3944	0.3962	0.3980	0.3997	0.4015
1.3	0.4032	0.4049	0.4066	0.4082	0.4099	0.4115	0.4131	0.4147	0.4162	0.4177
1.4	0.4192	0.4207	0.4222	0.4236	0.4251	0.4265	0.4279	0.4292	0.4306	0.4319
1.5	0.4332	0.4345	0.4357	0.4370	0.4382	0.4394	0.4406	0.4418	0.4429	0.4441
1.6	0.4452	0.4463	0.4474	0.4484	0.4495	0.4505	0.4515	0.4525	0.4535	0.4545
1.7	0.4554	0.4564	0.4573	0.4582	0.4591	0.4599	0.4608	0.4616	0.4625	0.4633
1.8	0.4641	0.4649	0.4656	0.4664	0.4671	0.4678	0.4686	0.4693	0.4699	0.4706
1.9	0.4713	0.4719	0.4726	0.4732	0.4738	0.4744	0.4750	0.4758	0.4761	0.4767
2.0	0.4772	0.4778	0.4783	0.4788	0.4793	0.4799	0.4803	0.4808	0.4812	0.4817
2.1	0.4821	0.4826	0.4830	0.4834	0.4838	0.4842	0.4846	0.4850	0.4854	0.4857
2.2	0.4861	0.4864	0.4868	0.4871	0.4875	0.4878	0.4881	0.4884	0.4887	0.4890
2.3	0.4893	0.4896	0.4898	0.4901	0.4904	0.4906	0.4909	0.4911	0.4913	0.4916
2.4	0.4918	0.4920	0.4922	0.4925	0.4927	0.4929	0.4931	0.4932	0.4934	0.4936
2.5	0.4938	0.4940	0.4941	0.4943	0.4945	0.4946	0.4948	0.4949	0.4951	0.4952
2.6	0.4953	0.4955	0.4956	0.4957	0.4959	0.4960	0.4961	0.4962	0.4963	0.4964
2.7	0.4965	0.4966	0.4967	0.4968	0.4969	0.4970	0.4971	0.4972	0.4973	0.4974
2.8	0.4974	0.4975	0.4976	0.4977	0.4977	0.4978	0.4979	0.4979	0.4980	0.4981
2.9	0.4981	0.4982	0.4982	0.4983	0.4984	0.4984	0.4985	0.4985	0.4986	0.4986
3.0	0.49865	0.4987	0.4987	0.4988	0.4988	0.4988	0.4989	0.4989	0.4989	0.4990

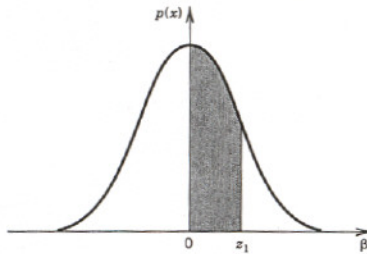


Figure 4.3 Integration terminology for the normal error function.

Table 4.4 Student-t Distribution

ν	t_{50}	t_{90}	t_{95}	t_{99}
1	1.000	6.314	12.706	63.657
2	0.816	2.920	4.303	9.925
3	0.765	2.353	3.182	5.841
4	0.741	2.132	2.770	4.604
5	0.727	2.015	2.571	4.032
6	0.718	1.943	2.447	3.707
7	0.711	1.895	2.365	3.499
8	0.706	1.860	2.306	3.355
9	0.703	1.833	2.262	3.250
10	0.700	1.812	2.228	3.169
11	0.697	1.796	2.201	3.106
12	0.695	1.782	2.179	3.055
13	0.694	1.771	2.160	3.012
14	0.692	1.761	2.145	2.977
15	0.691	1.753	2.131	2.947
16	0.690	1.746	2.120	2.921
17	0.689	1.740	2.110	2.898
18	0.688	1.734	2.101	2.878
19	0.688	1.729	2.093	2.861
20	0.687	1.725	2.086	2.845
21	0.686	1.721	2.080	2.831
30	0.683	1.697	2.042	2.750
40	0.681	1.684	2.021	2.704
50	0.680	1.679	2.010	2.679
60	0.679	1.671	2.000	2.660
∞	0.674	1.645	1.960	2.576