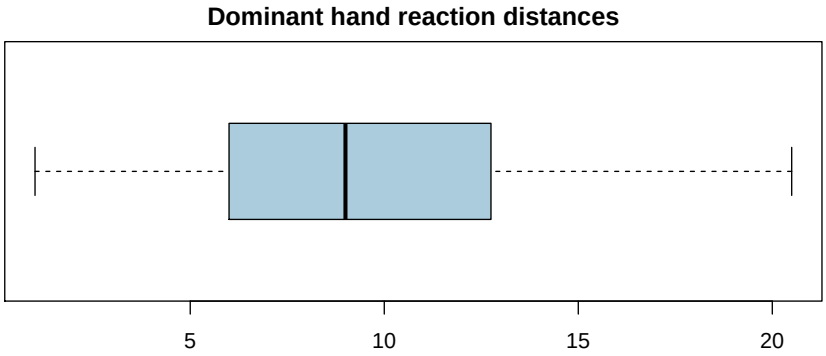
1. ***Reaction distance.*** Reaction distances (in centimeters) for the dominant hand were recorded from a random sample of 40 randomly chosen college students. Smaller distances indicate quicker reactions. A box plot of the distribution as well as summary statistics are provided below. A professor claims that college students have **quicker** reactions than the general population. The overall mean for the general population is 10 centimeters.



Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	SD	n
1.00	6.00	9.00	9.51	12.62	20.50	4.65	40

(a) What are the appropriate hypotheses for evaluating the professor's claim?

$$H_0 : \mu = 10$$
$$H_A : \mu < 10$$

(b) Check the conditions for conducting this hypothesis test. Your statements should be **in context** of the data and the research question.

(*Note:* You will not receive credit for simply listing the conditions, you must go through checking them in context to receive credit.)

1. *Independence: The students are sampled randomly and 40 ¡ 10% of all college students, therefore we can assume that the reaction distance of one student in the sample is independent of another.*
2. *Normality: The sample distribution is roughly symmetric (only maybe a tiny bit right skewed), indicating that the population distribution of all reaction times is also roughly symmetric. Also, sample size is greater than 30. With these, we can assume that the sampling distribution of the sample mean will be nearly normal (due to CLT).*

(c) Evaluate the professor's claim using a hypothesis test at the $\alpha = 0.05$ significance level. Make sure to interpret your results **in context** of the data and the research question.

$$SE = \frac{4.65}{\sqrt{40}} = 735$$
$$Z = \frac{9.51 - 10}{0.735} = -0.67$$
$$p - value = 0.25$$

The p-value is greater than the significance level, we fail to reject H0.
The data do not provide convincing evidence that college students have quicker reactions than the population at large.

(d) **Interpret** the p-value you calculated in the previous question **in context** of the data and the research question. Be concise and precise.

(*Note:* You are not asked to make a decision on the hypotheses – you should have already done that in the previous question. Instead, you must interpret the meaning of the p-value as a probability.)

If in fact the average reaction distance of college students is 10 centimeters,
there is a 25% chance of obtaining a random sample of 40 college students where the average reaction distance is 9.51 centimeters or less.

(e) Above, you conducted a hypothesis test with $\alpha = 0.05$. Next, you want to construct a confidence interval at the **equivalent confidence level**. Determine the appropriate confidence level.

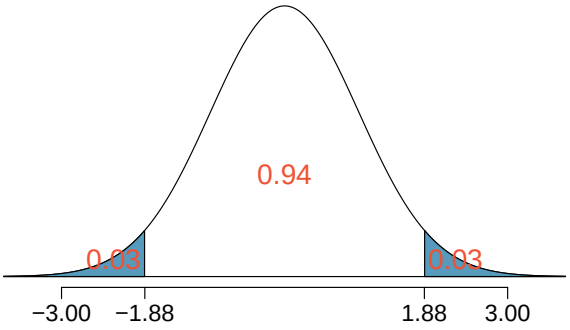
$CL = 1 - (2 * 0.05) = 0.90$

(f) Estimate the true average dominant hand reaction distance of college students using a confidence interval at an the confidence level determined in the previous question, and interpret this interval **in context** of the data and the research question.

$$z^\star_{90\%} = 1.65$$
$$9.51 \pm 1.65 * 0.735 = 9.51 \pm 1.21$$
$$= (8.3, 10.72)$$

We are 90% confident that the true average dominant hand reaction distance of college students is between 8.3 cm and 10.72 cm.

2. ***Epilepsy.*** A group of researchers want to test the possible effect of an epilepsy medication taken by pregnant mothers on the cognitive development of their children. As evidence, they want to estimate the IQ scores of three-year-old children born to mothers who were on this particular medication during pregnancy. Previous studies suggest that the standard deviation of IQ scores of three-year-old children is 18 points. How many such children should the researchers sample at a minimum in order to obtain a **94% confidence** interval with a margin of error **of maximum 4 points**?



$$
\begin{aligned}
Z^\star &= 1.88 \\
4 &\geq \frac{1.88 * 18}{\sqrt{n}} \\
n &\geq \left(\frac{1.88 * 18}{4}\right)^2 \\
n &\geq 71.57 \\
&\textit{at least } 72
\end{aligned}
$$

3. ***Spam.*** It is estimated that roughly 9% of incoming email is spam. A spam filter flags 90% of spam emails as spam, and incorrectly flags 2% of non-spam emails as spam.

   (a) What percent of all email is flagged as spam?

$$
\begin{aligned}
P(flagged\ spam) &= P(spam\ \&\ flagged\ spam) + P(not\ spam\ \&\ flagged\ spam) \\
&= 0.09 * 0.90 + 0.91 * 0.02 \\
&= 0.081 + 0.0182 \\
&= 0.0992
\end{aligned}
$$

   (b) If an email is flagged as spam, what is the probability that it is indeed a spam email?

$$
\begin{aligned}
P(spam \mid flagged\ spam) &= \frac{P(spam \& flagged\ spam)}{P(flagged\ spam)} \\
&= \frac{0.081}{0.0992} \\
&= 0.8165
\end{aligned}
$$

4. ***Calcium for treating blood pressure.*** Lyle et al. (1987) ran an experiment to study the effect of a calcium supplement on the blood pressure of African American males. A group of 10 men received a calcium supplement, and another group of 11 men received a placebo. The experiment lasted 12 weeks. Both before and after the 12-week period, each man had his systolic blood pressure measured while at rest. The changes in blood pressure are given in table below.

Calcium:	-5	-4	-3	-2	1	7	10	11	17	18	
Placebo:	-11	-5	-3	-3	-1	-1	-1	2	3	5	12

(a) What is the median change in the blood pressure in the **calcium** group?

$Median_{calcium} = \frac{1+7}{2} = 4$

(b) What is the median change in the blood pressure in the **placebo** group?

$Median_{placebo} = -1$

(c) We would like to test if the **median** change in blood pressure is **different** for the calcium and placebo groups. State the hypotheses for this test.

(*Note:* You can use notation, or you can state your hypotheses in words, but make sure that it's clear what type of test you're doing – one-sided vs. two-sided.)

$$H_0 : Median_{calcium} = Median_{placebo}$$
$$H_A : Median_{calcium} \neq Median_{placebo}$$

(d) Calculate the point estimate associated with these hypotheses.

$Median_{calcium} - Median_{placebo} = 5$

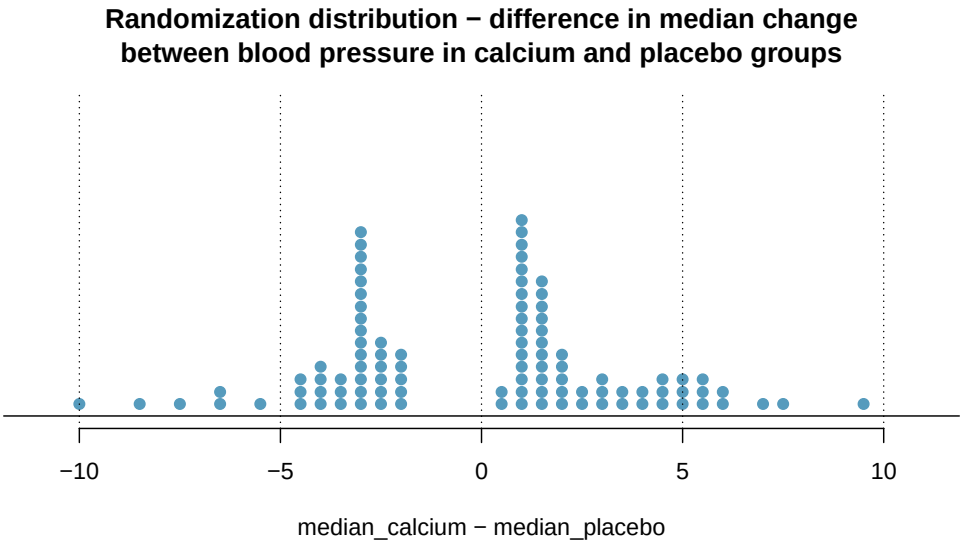
(e) Since theoretical methods do not apply to sampling distributions of medians, we use a randomization test. To do so, we write the change in blood pressure on 21 index cards. Then, we shuffle these cards and split them into two groups: one group of size 10 representing those receive a calcium supplement, and another group of size 11 representing those on the placebo. We calculate the difference between the medians in the simulated calcium and placebo distributions (as **calcium - placebo**), and record this value. Fill in the blanks in the remainder of this description.

We repeat this 100 times to build a randomization distribution, which should be centered at _____. Lastly, we calculate the p-value as the proportion of simulations where the simulated differences in medians is _____.

0, 5 or more or -5 or less

(f) Calculate the p-value based on the randomization distribution below. Note that the randomization test used 100 simulations.

$p - value$: _____



0.17

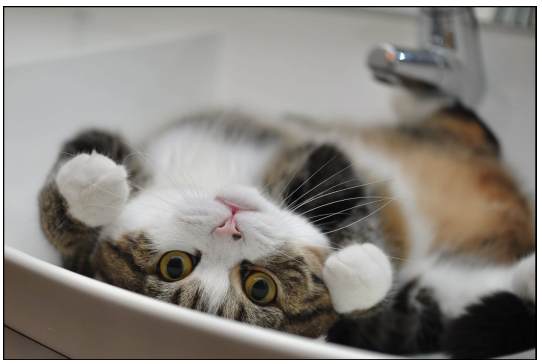
(g) Refer back to the research question: "Is there a difference in median change in blood pressure for the calcium and placebo groups?" What does the p-value you calculated in the previous question suggest? Choose one of the following:

(i) Reject H_0, there is evidence of a difference between the two groups.

(ii) ***Fail to reject H_0, there isn't sufficient evidence of a difference between the two groups.***

(iii) Accept H_0, there is evidence that the median in the two groups is the same.

5. ***Cats on YouTube.*** If you randomly select a video on YouTube, the probability that it involves a cat is 0.11. Over the course of a week, you watch 100 videos on YouTube using an app that randomly selects videos (the random video picker).



How many cat videos would you need to see to suspect that the random video picker is biased towards **or** against cat videos? You can provide a range if need be.

(*Hint:* Think about what would be considered an expected number of videos.)

$$\mu = np = 100 * 0.11 = 11$$
$$\sigma = \sqrt{100 * 0.11 * 0.89} = 3.13$$
$$\textit{Against: } 11 - (2 * 3.13) = 4.74$$
$$\textit{Towards: } 11 + (2 * 3.13) = 17.26$$

4 or fewer cat videos would indicate bias against, and 18 or more would indicate bias towards.

Short answer - Show your work where necessary.

6. ***Help out a friend.*** An absentminded (and not too clever) scientist friend of yours has just analyzed his data, and he has two numbers – 26.3 and 2.63 – written on a scrap of paper. He says: *"I remember that one of these is the standard deviation of my data and the other is the standard error of the mean, but I cant remember which is which. Can you help?"*

   (a) Which number is the standard deviation and which is the standard error of the mean?

   - standard deviation - Circle one: 26.3 2.63
   - standard error - Circle one: 26.3 2.63

   (b) What was your friends sample size? _____

   n = 100

7. ***Congress approval amid government shutdown.*** In a recent Gallup poll on a random sample of 1,028 US adults, 11% said they approve of the way the Congress is handling its job, with a 95% confidence interval of 7% to 15%. Which of the following statements is/are true based on the confidence interval? Circle **all** that apply.

   (*Note:* To get credit on this question you must circle all of the true statements, and not circle any of the false statements.)

   (i) The population proportion is 0.11.

   (ii) ***The sample proportion is 0.11.***

   (iii) ***The margin of error is 0.04.***

   (iv) 95% of random samples will have sample means between 0.07 and 0.15.

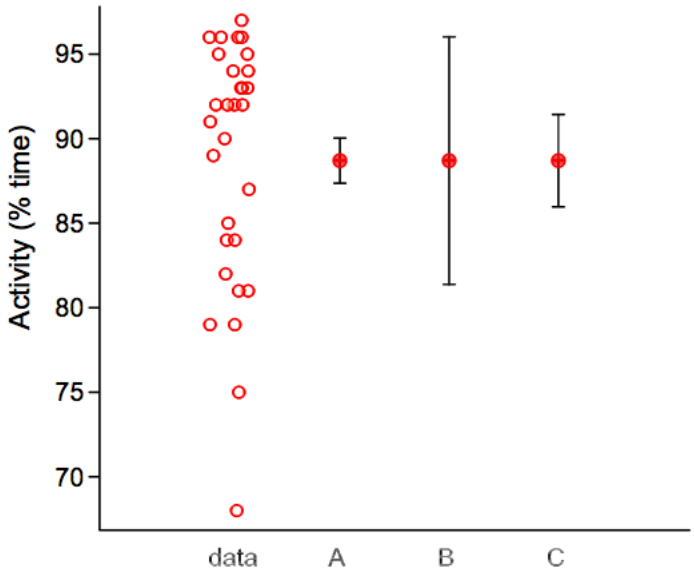
   (v) ***It is possible that the population proportion is 0.18.***

8. ***True / False.*** Determine if the following statements are true or false, and **circle** the appropriate letter (T or F). You do not need to provide your reasoning.

   (i) (T / F) Increasing α increases the power of the test. ***T***

   (ii) (T / F) You are going to collect income data from a right-skewed distribution of incomes of politicians. If you take a large enough sample, the distribution of the incomes of individuals in this sample will be nearly normal. ***F***

9. ***Is sleep necessary?.*** To investigate, Lesku et al. (2012) measured the activity patterns of breeding pectoral sandpipers (*Calidris melanotos*) in the high Arctic in summer, when the sun never sets. The accompanying figure shows the observed percent time that individual males were awake and active in a 2008 field study. The data are on the left. To the right of the data are the sample mean (filled circle) and error bars for the standard deviation, the standard error of the mean, and a 95% confidence interval for the mean **in no particular order**.



(a) Which of the error bars indicates the **standard deviation**? Circle one: A B C ***B***

(b) Which error bar indicates the **standard error** of the mean? Circle one: A B C ***A***

(c) Which error bar indicates a **95% confidence interval** for the mean? Circle one: A B C ***C***

Multiple choice - Choose the **best** answer. Fill in the bubbles on the first page of the exam. Each question is worth 2 points.

10. Spread of the sampling distribution for the sample mean is mainly determined by the magnitude of the

    (a) sample mean
    (b) ***sample size***
    (c) population mean
    (d) population size
    (e) confidence level

11. We create multiple sampling distributions, and record the standard error of each. The distributions are for the same point estimate from the same population, but each one is based on a different sample size. For each sampling distribution we record the size of the samples and the standard error of the distribution. The correlation between these two variables will be

    (a) zero
    (b) one
    (c) ***negative***
    (d) positive
    (e) none of the above

12. A behavioral economist designing an experiment to evaluate people's decision making patterns wants to make sure that males and females are equally represented in the treatment and control groups. Which of the following approaches will be **most** useful?

    (a) random sampling
    (b) random assignment
    (c) ***blocking***
    (d) clustering
    (e) blinding

13. The Washington Post and the New York Times conducted separate national polls where respondents were asked if they believe congress will reach a deal on the sequester. If the Washington Post surveyed 500 people and reported a 95% confidence interval while the New York Times surveyed 150 people and reported a 99% confidence interval. Which paper reported a **larger** margin of error?

    (a) The Washington Post

    (b) ***The New York Times***

    (c) The margin of errors are the same.

14. Which of the following is **true**?

    (a) Half the observations in a distribution of any shape have positive Z scores.

    (b) Majority of the values in a right skewed distribution have positive Z scores.

    (c) ***An observation with a Z score of*** $Z = +1.2$ ***is more unusual than an observation with a Z score of*** $Z = -0.5$***.***

    (d) The Z score for the median of a distribution of any shape is 0.

    (e) The median of a left skewed distribution has a negative Z score.

15. A research article reports the results of a new drug test. The drug is to be used to decrease symptoms in people with general anxiety disorder (GAD). The article gives a p-value of 0.035 in the analysis section. Which of the interpretations of the p-value is valid?

    (a) The probability that the drug is effective.

    (b) The probability that the drug is **not** effective.

    (c) The probability of getting results as extreme as or more extreme than the ones in this study if the drug is actually effective.

    (d) ***The probability of getting results as extreme as or more extreme than the ones in this study if the drug is actually not effective.***

Answer questions 16 to 17 based on the information below.

A June Gallup poll asked US residents about their opinion on sales taxes on internet purchases. The results of the poll are summarized in the table below. The text of the survey question is also provided above the table.

Next, suppose that on Election Day you could vote on key issues as well as candidates. Would you vote for or against a law that would allow each state to collect sales taxes on purchases its residents make online over the Internet?

	For	Against	No opinion
	%	%	%
National adults	39	57	4
18 to 29 years	27	73	0
30 to 49 years	35	62	3
50 to 64 years	50	46	4
65+ years	46	46	8

June 15-16, 2013

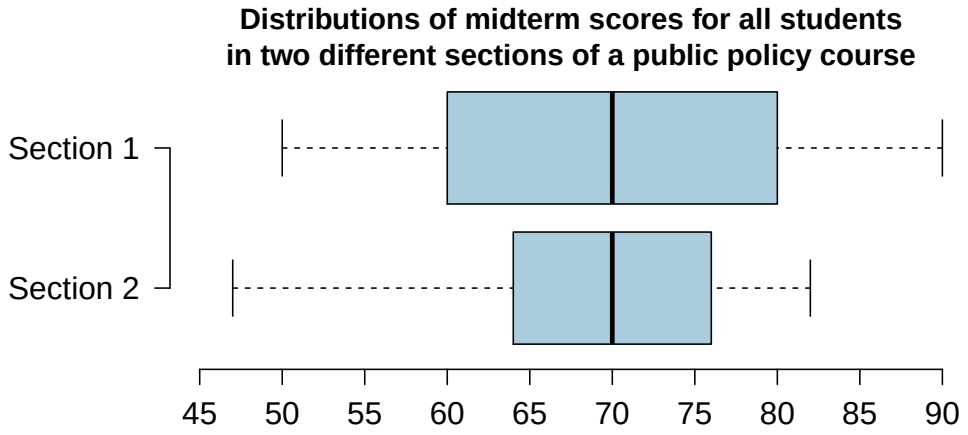
---

16. One of the values on the table is 73% (marked). Which of the following best describes this probability?
    (a) P(Against)
    (b) P(18 to 29 years)
    (c) P(18 to 29 years | Against)
    (d) ***P(Against | 18 to 29 years)***
    (e) P(Against & 18 to 29 years)

17. Based on these results, opinion on sales taxes on internet purchases and age appear to be
    (a) ***dependent***
    (b) independent
    (c) disjoint
    (d) mutually exclusive
    (e) complementary

Answer questions 18 to ?? based on the information below.

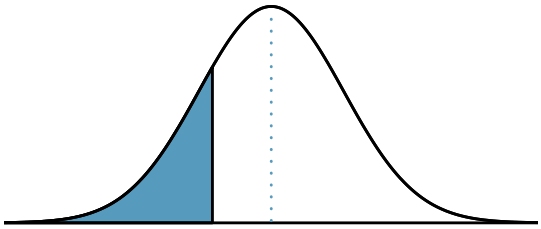
The two box plots below display distributions of midterm scores for all students in two different sections of a public policy course.



---

18. Which section has a greater percentage of students with scores below 55?
    (a) Section 1
    (b) Section 2
    (c) Both sections are about equal
    (d) ***It is impossible to tell***

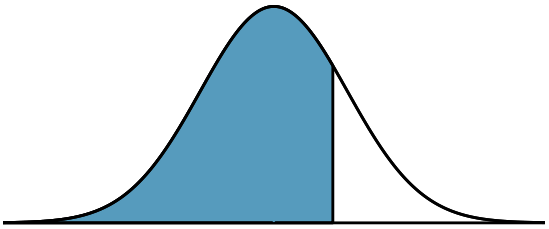
19. Which section has a greater percentage of students with scores above 70?
    (a) Section 1
    (b) Section 2
    (c) ***Both sections are about equal***
    (d) It is impossible to tell



negative Z

Second decimal place of Z										
0.09	0.08	0.07	0.06	0.05	0.04	0.03	0.02	0.01	0.00	Z
0.0002	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	−3.4
0.0003	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0005	0.0005	0.0005	−3.3
0.0005	0.0005	0.0005	0.0006	0.0006	0.0006	0.0006	0.0006	0.0007	0.0007	−3.2
0.0007	0.0007	0.0008	0.0008	0.0008	0.0008	0.0009	0.0009	0.0009	0.0010	−3.1
0.0010	0.0010	0.0011	0.0011	0.0011	0.0012	0.0012	0.0013	0.0013	0.0013	−3.0
0.0014	0.0014	0.0015	0.0015	0.0016	0.0016	0.0017	0.0018	0.0018	0.0019	−2.9
0.0019	0.0020	0.0021	0.0021	0.0022	0.0023	0.0023	0.0024	0.0025	0.0026	−2.8
0.0026	0.0027	0.0028	0.0029	0.0030	0.0031	0.0032	0.0033	0.0034	0.0035	−2.7
0.0036	0.0037	0.0038	0.0039	0.0040	0.0041	0.0043	0.0044	0.0045	0.0047	−2.6
0.0048	0.0049	0.0051	0.0052	0.0054	0.0055	0.0057	0.0059	0.0060	0.0062	−2.5
0.0064	0.0066	0.0068	0.0069	0.0071	0.0073	0.0075	0.0078	0.0080	0.0082	−2.4
0.0084	0.0087	0.0089	0.0091	0.0094	0.0096	0.0099	0.0102	0.0104	0.0107	−2.3
0.0110	0.0113	0.0116	0.0119	0.0122	0.0125	0.0129	0.0132	0.0136	0.0139	−2.2
0.0143	0.0146	0.0150	0.0154	0.0158	0.0162	0.0166	0.0170	0.0174	0.0179	−2.1
0.0183	0.0188	0.0192	0.0197	0.0202	0.0207	0.0212	0.0217	0.0222	0.0228	−2.0
0.0233	0.0239	0.0244	0.0250	0.0256	0.0262	0.0268	0.0274	0.0281	0.0287	−1.9
0.0294	0.0301	0.0307	0.0314	0.0322	0.0329	0.0336	0.0344	0.0351	0.0359	−1.8
0.0367	0.0375	0.0384	0.0392	0.0401	0.0409	0.0418	0.0427	0.0436	0.0446	−1.7
0.0455	0.0465	0.0475	0.0485	0.0495	0.0505	0.0516	0.0526	0.0537	0.0548	−1.6
0.0559	0.0571	0.0582	0.0594	0.0606	0.0618	0.0630	0.0643	0.0655	0.0668	−1.5
0.0681	0.0694	0.0708	0.0721	0.0735	0.0749	0.0764	0.0778	0.0793	0.0808	−1.4
0.0823	0.0838	0.0853	0.0869	0.0885	0.0901	0.0918	0.0934	0.0951	0.0968	−1.3
0.0985	0.1003	0.1020	0.1038	0.1056	0.1075	0.1093	0.1112	0.1131	0.1151	−1.2
0.1170	0.1190	0.1210	0.1230	0.1251	0.1271	0.1292	0.1314	0.1335	0.1357	−1.1
0.1379	0.1401	0.1423	0.1446	0.1469	0.1492	0.1515	0.1539	0.1562	0.1587	−1.0
0.1611	0.1635	0.1660	0.1685	0.1711	0.1736	0.1762	0.1788	0.1814	0.1841	−0.9
0.1867	0.1894	0.1922	0.1949	0.1977	0.2005	0.2033	0.2061	0.2090	0.2119	−0.8
0.2148	0.2177	0.2206	0.2236	0.2266	0.2296	0.2327	0.2358	0.2389	0.2420	−0.7
0.2451	0.2483	0.2514	0.2546	0.2578	0.2611	0.2643	0.2676	0.2709	0.2743	−0.6
0.2776	0.2810	0.2843	0.2877	0.2912	0.2946	0.2981	0.3015	0.3050	0.3085	−0.5
0.3121	0.3156	0.3192	0.3228	0.3264	0.3300	0.3336	0.3372	0.3409	0.3446	−0.4
0.3483	0.3520	0.3557	0.3594	0.3632	0.3669	0.3707	0.3745	0.3783	0.3821	−0.3
0.3859	0.3897	0.3936	0.3974	0.4013	0.4052	0.4090	0.4129	0.4168	0.4207	−0.2
0.4247	0.4286	0.4325	0.4364	0.4404	0.4443	0.4483	0.4522	0.4562	0.4602	−0.1
0.4641	0.4681	0.4721	0.4761	0.4801	0.4840	0.4880	0.4920	0.4960	0.5000	−0.0

*For $Z \leq -3.50$, the probability is less than or equal to 0.0002.



positive Z

	Second decimal place of Z									
Z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.0	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3.0	0.9987	0.9987	0.9987	0.9988	0.9988	0.9989	0.9989	0.9989	0.9990	0.9990
3.1	0.9990	0.9991	0.9991	0.9991	0.9992	0.9992	0.9992	0.9992	0.9993	0.9993
3.2	0.9993	0.9993	0.9994	0.9994	0.9994	0.9994	0.9994	0.9995	0.9995	0.9995
3.3	0.9995	0.9995	0.9995	0.9996	0.9996	0.9996	0.9996	0.9996	0.9996	0.9997
3.4	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9998

*For $Z \geq 3.50$, the probability is greater than or equal to 0.9998.