SULIT

KEMENTERIAN PENDIDIKAN TINGGI
JABATAN PENDIDIKAN POLITEKNIK DAN KOLEJ KOMUNITI

BAHAGIAN PEPERIKSAAN DAN PENILAIAN
JABATAN PENDIDIKAN POLITEKNIK DAN KOLEJ KOMUNITI
KEMENTERIAN PENDIDIKAN TINGGI

JABATAN MATEMATIK, SAINS DAN KOMPUTER

PEPERIKSAAN AKHIR

**SESI I : 2025/2026**

# DBM30263: STATISTICS AND PROBABILITY

**TARIKH : 24 NOVEMBER 2025**

**MASA : 2.30 PETANG-4.30 PETANG (2 JAM)**

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Kertas ini mengandungi **SEMBILAN (9)** halaman bercetak.

Struktur (4 soalan)

Dokumen sokongan yang disertakan : Formula

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**JANGAN BUKA KERTAS SOALAN INI SEHINGGA DIARAHKAN**

(CLO yang tertera hanya sebagai rujukan)

**INSTRUCTION:**

This section consists of **FOUR (4)** structured questions. Answers **ALL** questions.

***ARAHAN:***

*Bahagian ini mengandungi **EMPAT (4)** soalan berstruktur. Jawab **SEMUA** soalan.*

**QUESTION 1**

***SOALAN 1***

CLO1 (a) Variables are the foundation of statistical analysis because they represent data collected and analyzed.

*Pembolehubah merupakan asas kepada analisis statistic kerana ia diwakili data yang dikumpul dan dianalisis.*

i. Explain **TWO (2)** types of random variables.

*Terangkan **DUA (2)** jenis pembolehubah rawak.*

[2 marks]

[*2 markah*]

ii. Simplify **TWO (2)** examples for each type discrete and continuous variable.

*Ringkaskan **DUA (2)** contoh untuk setiap jenis pembolehubah diskret dan selanjar.*

[4 marks]

[*4 markah*]

CLO1 (b) Probability distribution table for discrete random variables is given below:

*Jadual taburan kebarangkalian untuk pembolehubah rawak diskret diberikan di bawah:*

| x | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| P(x) | 0.13 | 0.25 | 0.33 | 0.29 |

i. Calculate the mean

*Kirakan min*

[3 marks]

[*3 markah*]

ii. Calculate the standard deviation (3 decimal places).

*Kirakan sisihan piawai (3 titik perpuluhan).*

[6 marks]

[*6 markah*]

CLO1 (c) In statistics and probability, situation often analyzed involving selection and random events.

*Dalam statistik dan kebarangkalian, situasi yang sering dianalisis melibatkan pemilihan dan peristiwa rawak.*

i. Calculate how many ways we can select a committee of two women and three men from a group of five distinct women and six distinct men.

*Kira berapakah bilangan cara untuk memilih sebuah jawatankuasa yang terdiri daripada dua orang wanita dan tiga orang lelaki daripada satu kumpulan yang mempunyai lima wanita berbeza dan enam lelaki berbeza.*

[6 marks]

[*6 markah*]

ii. A software system averages 7 errors per 3,000 lines of code. Calculate the probability of exactly 2 errors in 3,000 lines of randomly selected lines of code.

*Satu sistem perisian secara purata mempunyai 7 ralat bagi setiap 3,000 baris kod. Kira kebarangkalian berlakunya tepat 2 ralat dalam 3,000 baris kod yang dipilih secara rawak?*

[4 marks]

[*4 markah*]

**QUESTION 2**

***SOALAN 2***

CLO1

(a) Normal distribution is a type of continuous probability distribution describing how the values of random variable are distributed.

*Taburan normal ialah sejenis taburan kebarangkalian berterusan yang menerangkan bagaimana nilai-nilai bagi suatu pembolehubah rawak diagihkan.*

i. A continuous random variable X is normally distributed with a mean of 15 and an unknown standard deviation $\sigma$, that is $X \sim N\ (\ 15, \sigma^2\ )$ and $P(\ X\ \geq\ 8\ )\ =\ 0.6844$, calculate the value of $\sigma$.

*Satu pembolehubah rawak berterusan X mengikut taburan normal dengan min 15 dan sisihan piawai yang tidak diketahui σ, iaitu* $X \sim N\ (\ 15, \sigma^2\ )$ *and* $P(\ X\ \geq\ 8\ )\ =\ 0.6844$, *kirakan nilai σ.*

[5 marks]

[*5 markah*]

ii. A normal distribution has mean (μ) = 50 and standard deviation (σ) = 5. Calculate the probability of a random observation falling between 45 and 55 by using the Z-score.

*Satu taburan Normal mempunyai min (μ) = 50 dan sisihan piawai (σ) = 5. Kirakan kebarangkalian bagi pemerhatian rawak yang terletak antara 45 hingga 55 dengan menggunakan skor-Z.*

[5 marks]

[*5 markah*]

CLO1

(b) Mr Ali's farm management team is preparing a report based on recent data collected.

*Pasukan pengurusan ladang Encik Ali sedang menyediakan laporan berdasarkan data terkini.*

i. The weight of the freshly picked melons from the garden of Mr. Ali is normally distributed with a mean (μ) and a standard deviation ($\sigma$). It is given that 2.28% of the melons weight less than 1.5 kg and 25.23% of the melons weight more than 3.5 kg. Solve μ and $\sigma$ of the freshly picked melon.

*Berat tembikai madu yang baru dikutip di kebun tembikai Encik Ali mengikut taburan normal dengan min (μ) dan sisihan piawai ($\sigma$). Diberi bahawa 2.28% buah tembikai madu itu mempunyai berat kurang daripada 1.5 kg dan 25.23% buah tembikai madu mempunyai berat lebih daripada 3.5 kg. Selesaikan μ dan σ bagi berat buah tembikai yang baru dikutip.*

[8 marks]

[*8 markah*]

ii. The time taken by Mr Ali to pick melons from his garden is normally distributed with mean of 35 minutes and a variance of 20.25 minutes$^2$. Solve the probability that Mr Ali takes more than 44 minutes and given that 56% of the times taken are less than k minutes, calculate the value of $k$.

*Masa yang diambil oleh Encik Ali untuk memetik tembikai dari kebunnya adalah diagihkan secara normal dengan min 35 minit dan varians 20.25 minit$^2$. Kira kebarangkalian bahawa Encik Ali mengambil masa lebih daripada 44 minit untuk memetik tembikai dan diberi bahawa 56% daripada masa yang diambil adalah kurang daripada k minit, kirakan nilai k.*

[7 marks]

[*7 markah*]

**QUESTION 3**

***SOALAN 3***

CLO1

(a) A software tester runs 60 test cases on a new application. Each test case has a probability of 0.3 to fail, independently.

*Seorang penguji perisian menjalankan 60 kes ujian pada aplikasi baru. Setiap kes ujian mempunyai kebarangkalian 0.3 untuk gagal, secara bebas.*

i. Using the Binomial model, solve the mean and standard deviation of the number of failed test cases.

*Dengan menggunakan model Binomial, selesaikan min dan sisihan piawai bagi bilangan kes ujian yang gagal.*

[5 marks]

[*5 markah*]

ii. Using the Normal approximation with z-score and continuity correction, solve the probability that not less than 20 test cases fail.

*Dengan menggunakan penghampiran Normal melalui z-score dan pembetulan kesinambungan (continuity correction), selesaikan kebarangkalian bahawa tidak kurang daripada 20 kes ujian gagal.*

[5 marks]

[*5 markah*]

CLO1

(b) A web server receives 100 independent requests. Each request has a 0.8 probability of being processed within 1 second.

*Sebuah pelayan web menerima 100 permintaan secara bebas. Setiap permintaan mempunyai kebarangkalian 0.8 untuk diproses dalam masa 1 saat.*

i. Determine the suitable distribution for the number of requests processed on time, its mean ($\mu$) and standard deviation ($\sigma$).

*Tentukan taburan yang sesuai bagi bilangan permintaan yang diproses tepat pada masanya, min ($\mu$) dan sisihan piawai ($\sigma$).*

[5 marks]

[*5 markah*]

ii. Solve, using the Normal approximation to the Binomial distribution with continuity correction, the probability that exactly 85 requests are processed on time, including z-score steps and the final numerical answer.
*Selesaikan, menggunakan penghampiran Normal kepada taburan Binomial dengan pembetulan kesinambungan, kebarangkalian bahawa tepat 85 permintaan diproses tepat pada masanya, termasuk langkah z-skor dan jawapan berangka akhir.*

[9 marks]
[*9 markah*]

iii. Based on 3.b) ii. construct the meaning of the probability value in the context of web server performance.
*Berdasarkan jawapan di 3.b)ii. bina maksud nilai kebarangkalian tersebut dalam konteks prestasi pelayan web.*

[1 mark]
[*1 markah*]

**QUESTION 4**

***SOALAN 4***

CLO1

(a) Describe:

*Terangkan:*

i. The difference between a census and a sample survey.

*Perbezaan antara bancian dan tinjauan sampel.*

[2 marks]

[*2 markah*]

ii. Point and interval estimation with **ONE (1)** example each.

*Anggaran titik dan anggaran selang dengan **SATU (1)** contoh masing-masing.*

[4 marks]

[*4 markah*]

(b) A random sample of 10 response times (in milliseconds) is recorded from a web server: 91, 91, 113, 107, 98. The sample mean is $99.4\,ms$. Assume the response times are normally distributed with variance 400.

*Satu sampel rawak 10 masa tindak balas (dalam milisaat) direkodkan daripada sebuah pelayan web:* 91, 91, 113, 107, 98. *Purata sampel ialah 99.4 ms. Andaikan masa tindak balas ini beragih normal dengan varians 400.*

i. Solve the unbiased estimate for the population variance ($\sigma^2$).

*Selesaikan anggaran tak berat sebelah bagi varians populasi ($\sigma^2$).*

[4 marks]

[*4 markah*]

ii. Calculate the 95% confidence interval for the mean server response time.

*Hitung selang keyakinan 95% bagi min masa tindak balas.*

[5 marks]

[*5 markah*]

(c) i. Perodua automotive-parts wholesaler needs an estimate of the mean lifespan they can expect from windshield wiper blades under typical driving conditions. Solve an interval estimates with a coefficient level of 95 percent, based on the $n = 120, \bar{x} = 23$ months, population standard deviation $(\sigma) = 7$ months.

*Pemborong alat ganti automotif Perodua memerlukan anggaran jangka hayat purata yang boleh dijangka daripada bilah pengelap cermin depan dalam keadaan pemanduan biasa. Selesaikan anggaran selang dengan tahap pekali 95 peratus, berdasarkan* $n = 120, \bar{x} = 23$ *bulan, sisihan piawai populasi* $(\sigma) = 7$ *bulan.*

[5 marks]

[*5 markah*]

ii. A random sample of $n = 64$ observation has a mean equal to 29.1 and a standard deviation of 3.9. Give the point estimate for the population mean, $\mu$ and calculate the margin of error in estimation. The confidence level for this case is 95%.

*Sampel rawak n = 64 pemerhatian mempunyai min sama dengan 29.1 dan sisihan piawai 3.9. Berikan anggaran mata untuk min populasi,* $\mu$ *dan kirakan margin ralat dalam anggaran. Nilai tahap keyakinan untuk kes ini adalah 95%.*

[5 marks]

[*5 markah*]

**SOALAN TAMAT**

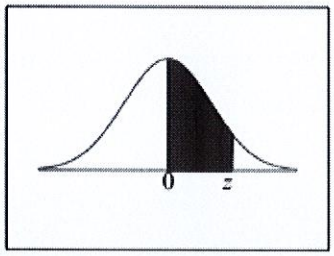
# FORMULA SHEET FOR DBM30263: STATISTICS AND PROBABILITY

| PROBABILITY DISTRIBUTIONS | | | |
|---|---|---|---|
| 1 | Sample Mean, $\bar{x}$<br>$\bar{x} = \frac{\Sigma xi}{n}$ | 8 | Variance of Discrete Random Variables<br>$\sigma^2 = E(X-\mu)^2 = \sum_x (x-\mu)^2 . P(X=x)$<br>$= \sum_x x^2 . P(X=x) - \mu^2$ |
| 2 | Sample Standard Deviation, s<br>$s = \sqrt{\frac{\sum(xi-\bar{x})^2}{n-1}}$ | 9 | Factorials<br>$\binom{n}{r} = \frac{n!}{r!\,(n-r)!}$ |
| 3 | Variance (Population)<br>$\sigma^2 = \frac{\sum(x_i-\mu)^2}{N}$ | 10 | Combinations<br>$nC_r = \frac{n!}{(n-r)!\,r!}$<br>Or<br>$C(n,r) = nC_r = \frac{n!}{(n-r)!\,r!}$ |
| 4 | Variance (Sample)<br>$s^2 = \frac{\sum(x_i-\bar{x})^2}{n-1}$ | 11 | Binomial Probability Distributions<br>$P(X=k) = \binom{n}{x} p^k q^{n-k}$<br>$where\ k = 0,1,2,\ldots n$<br>$P(X=x) = nCx . p^x q^{n-x} = \frac{n!}{x!\,(n-x)!} p^x q^{n-x}$<br>Or<br>$P(x) = \binom{n}{x} . p^x . q^{n-x}$ |
| 5 | Mean of Discrete Random Variable<br>$E(x) = \mu = \sum_x x \cdot P(X=x)$ | 12 | Mean of Binomial Random Variable<br>$\mu = np \ \ or \mu = n.p$ |
| 6 | Standard Deviation of Discrete Random Variable<br>$\sigma = \sqrt{\sum_x (x-\mu)^2 . P(X=x)}$<br>Or<br>$\sigma = \sqrt{\left[\sum_x x^2 . P(X=x)\right] - \mu^2}$ | 13 | Standard Deviation of Binomial Random Variable<br>$\sigma = \sqrt{np(1-p)}$ |
| 7 | Variance of Binomial Random Variable<br>$\sigma^2 = npq$ | 14 | Poisson Probability Distribution<br>$P(X=k) = \frac{\lambda^k e^{-\lambda}}{k!}$ |

| | | | |
|---|---|---|---|
| 15 | Mean of Poisson Probability Distribution<br>$\mu = \lambda$ | 17 | Variance of Poisson Probability Distribution<br>$\sigma^2 = \lambda$ |
| 16 | Probability Density Function<br>$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{-(x-\mu)^2}{2\sigma^2}}$ | 18 | Standard Normal Distribution<br>$z = \frac{\chi - \mu}{\sigma}$ |
| 19 | Continuity Correction<br>(a) $P(X \geq a) = P(X > a - 0.5)$<br>(b) $P(X > a) = P(X > a + 0.5)$<br>(c) $P(X \leq a) = P(X < a + 0.5)$<br>(d) $P(X < a) = P(X < a - 0.5)$<br>(e) $P(a \leq X \leq b) = P(a - 0.5 < X < b + 0.5)$<br>(f) $P(a < X < b) = P(a + 0.5 < X < b - 0.5)$<br>(g) $P(X = a) = P(a - 0.5 < X < a + 0.5)$ | | |

| **SAMPLING AND ESTIMATION** | | | |
|---|---|---|---|
| 1 | Estimator for Sample Mean<br>$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$ | 7 | Maximum Error for Large Samples<br>$E = z\left(\frac{\sigma}{\sqrt{n}}\right)$ |
| 2 | Estimator for Sample Proportion<br>$\hat{p} = \frac{x}{n}$ | 8 | Confidence Interval for Small Samples<br>$CI = \bar{x} \pm t_{a/2}\left(\frac{s}{\sqrt{n}}\right)$ |
| 3 | Estimator for Population Standard Deviation<br>(Sample Standard Deviation)<br>$s = \sqrt{\frac{\sum(xi - \bar{x})^2}{n-1}}$ | 9 | Degree of Freedom<br>$df = n - 1$ |
| 4 | Confidence Interval for Population Mean<br>$CI = \bar{x} \pm z_{a/2}\left(\frac{\sigma}{\sqrt{n}}\right)$ | 10 | Confidence Interval for Population Proportion<br>$\hat{p} \pm z_{a/2}\left(\sqrt{\frac{\hat{p}(1-\hat{p})}{n}}\right)$ |
| 5 | Confidence Interval for Large Samples<br>$CI = \bar{x} \pm z_{a/2}\left(\frac{\sigma}{\sqrt{n}}\right)$ | 11 | Critical t-value<br>$t_{a/2}$ |
| 6 | Standard Error of Mean (SEM)<br>$SEM: \frac{\sigma}{\sqrt{n}}$ | 12 | Critical z-value<br>$z_{a/2}$ |

# Standard Normal Distribution Table




| z | .00 | .01 | .02 | .03 | .04 | .05 | .06 | .07 | .08 | .09 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | .0000 | .0040 | .0080 | .0120 | .0160 | .0199 | .0239 | .0279 | .0319 | .0359 |
| 0.1 | .0398 | .0438 | .0478 | .0517 | .0557 | .0596 | .0636 | .0675 | .0714 | .0753 |
| 0.2 | .0793 | .0832 | .0871 | .0910 | .0948 | .0987 | .1026 | .1064 | .1103 | .1141 |
| 0.3 | .1179 | .1217 | .1255 | .1293 | .1331 | .1368 | .1406 | .1443 | .1480 | .1517 |
| 0.4 | .1554 | .1591 | .1628 | .1664 | .1700 | .1736 | .1772 | .1808 | .1844 | .1879 |
| 0.5 | .1915 | .1950 | .1985 | .2019 | .2054 | .2088 | .2123 | .2157 | .2190 | .2224 |
| 0.6 | .2257 | .2291 | .2324 | .2357 | .2389 | .2422 | .2454 | .2486 | .2517 | .2549 |
| 0.7 | .2580 | .2611 | .2642 | .2673 | .2704 | .2734 | .2764 | .2794 | .2823 | .2852 |
| 0.8 | .2881 | .2910 | .2939 | .2967 | .2995 | .3023 | .3051 | .3078 | .3106 | .3133 |
| 0.9 | .3159 | .3186 | .3212 | .3238 | .3264 | .3289 | .3315 | .3340 | .3365 | .3389 |
| 1.0 | .3413 | .3438 | .3461 | .3485 | .3508 | .3531 | .3554 | .3577 | .3599 | .3621 |
| 1.1 | .3643 | .3665 | .3686 | .3708 | .3729 | .3749 | .3770 | .3790 | .3810 | .3830 |
| 1.2 | .3849 | .3869 | .3888 | .3907 | .3925 | .3944 | .3962 | .3980 | .3997 | .4015 |
| 1.3 | .4032 | .4049 | .4066 | .4082 | .4099 | .4115 | .4131 | .4147 | .4162 | .4177 |
| 1.4 | .4192 | .4207 | .4222 | .4236 | .4251 | .4265 | .4279 | .4292 | .4306 | .4319 |
| 1.5 | .4332 | .4345 | .4357 | .4370 | .4382 | .4394 | .4406 | .4418 | .4429 | .4441 |
| 1.6 | .4452 | .4463 | .4474 | .4484 | .4495 | .4505 | .4515 | .4525 | .4535 | .4545 |
| 1.7 | .4554 | .4564 | .4573 | .4582 | .4591 | .4599 | .4608 | .4616 | .4625 | .4633 |
| 1.8 | .4641 | .4649 | .4656 | .4664 | .4671 | .4678 | .4686 | .4693 | .4699 | .4706 |
| 1.9 | .4713 | .4719 | .4726 | .4732 | .4738 | .4744 | .4750 | .4756 | .4761 | .4767 |
| 2.0 | .4772 | .4778 | .4783 | .4788 | .4793 | .4798 | .4803 | .4808 | .4812 | .4817 |
| 2.1 | .4821 | .4826 | .4830 | .4834 | .4838 | .4842 | .4846 | .4850 | .4854 | .4857 |
| 2.2 | .4861 | .4864 | .4868 | .4871 | .4875 | .4878 | .4881 | .4884 | .4887 | .4890 |
| 2.3 | .4893 | .4896 | .4898 | .4901 | .4904 | .4906 | .4909 | .4911 | .4913 | .4916 |
| 2.4 | .4918 | .4920 | .4922 | .4925 | .4927 | .4929 | .4931 | .4932 | .4934 | .4936 |
| 2.5 | .4938 | .4940 | .4941 | .4943 | .4945 | .4946 | .4948 | .4949 | .4951 | .4952 |
| 2.6 | .4953 | .4955 | .4956 | .4957 | .4959 | .4960 | .4961 | .4962 | .4963 | .4964 |
| 2.7 | .4965 | .4966 | .4967 | .4968 | .4969 | .4970 | .4971 | .4972 | .4973 | .4974 |
| 2.8 | .4974 | .4975 | .4976 | .4977 | .4977 | .4978 | .4979 | .4979 | .4980 | .4981 |
| 2.9 | .4981 | .4982 | .4982 | .4983 | .4984 | .4984 | .4985 | .4985 | .4986 | .4986 |
| 3.0 | .4987 | .4987 | .4987 | .4988 | .4988 | .4989 | .4989 | .4989 | .4990 | .4990 |
| 3.1 | .4990 | .4991 | .4991 | .4991 | .4992 | .4992 | .4992 | .4992 | .4993 | .4993 |
| 3.2 | .4993 | .4993 | .4994 | .4994 | .4994 | .4994 | .4994 | .4995 | .4995 | .4995 |
| 3.3 | .4995 | .4995 | .4995 | .4996 | .4996 | .4996 | .4996 | .4996 | .4996 | .4997 |
| 3.4 | .4997 | .4997 | .4997 | .4997 | .4997 | .4997 | .4997 | .4997 | .4997 | .4998 |
| 3.5 | .4998 | .4998 | .4998 | .4998 | .4998 | .4998 | .4998 | .4998 | .4998 | .4998 |

Z-Table

| z | .00 | .01 | .02 | .03 | .04 | .05 | .06 | .07 | .08 | .09 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | .5000 | .5040 | .5080 | .5120 | .5160 | .5199 | .5239 | .5279 | .5319 | .5359 |
| 0.1 | .5398 | .5438 | .5478 | .5517 | .5557 | .5596 | .5636 | .5675 | .5714 | .5753 |
| 0.2 | .5793 | .5832 | .5871 | .5910 | .5948 | .5987 | .6026 | .6064 | .6103 | .6141 |
| 0.3 | .6179 | .6217 | .6255 | .6293 | .6331 | .6368 | .6406 | .6443 | .6480 | .6517 |
| 0.4 | .6554 | .6591 | .6628 | .6664 | .6700 | .6736 | .6772 | .6808 | .6844 | .6879 |
| 0.5 | .6915 | .6950 | .6985 | .7019 | .7054 | .7088 | .7123 | .7157 | .7190 | .7224 |
| 0.6 | .7257 | .7291 | .7324 | .7357 | .7389 | .7422 | .7454 | .7486 | .7517 | .7549 |
| 0.7 | .7580 | .7611 | .7642 | .7673 | .7704 | .7734 | .7764 | .7794 | .7823 | .7852 |
| 0.8 | .7881 | .7910 | .7939 | .7967 | .7995 | .8023 | .8051 | .8078 | .8106 | .8133 |
| 0.9 | .8159 | .8186 | .8212 | .8238 | .8264 | .8289 | .8315 | .8340 | .8365 | .8389 |
| 1.0 | .8413 | .8438 | .8461 | .8485 | .8508 | .8531 | .8554 | .8577 | .8599 | .8621 |
| 1.1 | .8643 | .8665 | .8686 | .8708 | .8729 | .8749 | .8770 | .8790 | .8810 | .8830 |
| 1.2 | .8849 | .8869 | .8888 | .8907 | .8925 | .8944 | .8962 | .8980 | .8997 | .9015 |
| 1.3 | .9032 | .9049 | .9066 | .9082 | .9099 | .9115 | .9131 | .9147 | .9162 | .9177 |
| 1.4 | .9192 | .9207 | .9222 | .9236 | .9251 | .9265 | .9279 | .9292 | .9306 | .9319 |
| 1.5 | .9332 | .9345 | .9357 | .9370 | .9382 | .9394 | .9406 | .9418 | .9429 | .9441 |
| 1.6 | .9452 | .9463 | .9474 | .9484 | .9495 | .9505 | .9515 | .9525 | .9535 | .9545 |
| 1.7 | .9554 | .9564 | .9573 | .9582 | .9591 | .9599 | .9608 | .9616 | .9625 | .9633 |
| 1.8 | .9641 | .9649 | .9656 | .9664 | .9671 | .9678 | .9686 | .9693 | .9699 | .9706 |
| 1.9 | .9713 | .9719 | .9726 | .9732 | .9738 | .9744 | .9750 | .9756 | .9761 | .9767 |
| 2.0 | .9772 | .9778 | .9783 | .9788 | .9793 | .9798 | .9803 | .9808 | .9812 | .9817 |
| 2.1 | .9821 | .9826 | .9830 | .9834 | .9838 | .9842 | .9846 | .9850 | .9854 | .9857 |
| 2.2 | .9861 | .9864 | .9868 | .9871 | .9875 | .9878 | .9881 | .9884 | .9887 | .9890 |
| 2.3 | .9893 | .9896 | .9898 | .9901 | .9904 | .9906 | .9909 | .9911 | .9913 | .9916 |
| 2.4 | .9918 | .9920 | .9922 | .9925 | .9927 | .9929 | .9931 | .9932 | .9934 | .9936 |
| 2.5 | .9938 | .9940 | .9941 | .9943 | .9945 | .9946 | .9948 | .9949 | .9951 | .9952 |
| 2.6 | .9953 | .9955 | .9956 | .9957 | .9959 | .9960 | .9961 | .9962 | .9963 | .9964 |
| 2.7 | .9965 | .9966 | .9967 | .9968 | .9969 | .9970 | .9971 | .9972 | .9973 | .9974 |
| 2.8 | .9974 | .9975 | .9976 | .9977 | .9977 | .9978 | .9979 | .9979 | .9980 | .9981 |
| 2.9 | .9981 | .9982 | .9982 | .9983 | .9984 | .9984 | .9985 | .9985 | .9986 | .9986 |
| 3.0 | .9987 | .9987 | .9987 | .9988 | .9988 | .9989 | .9989 | .9989 | .9990 | .9990 |
| 3.1 | .9990 | .9991 | .9991 | .9991 | .9992 | .9992 | .9992 | .9992 | .9993 | .9993 |
| 3.2 | .9993 | .9993 | .9994 | .9994 | .9994 | .9994 | .9994 | .9995 | .9995 | .9995 |
| 3.3 | .9995 | .9995 | .9995 | .9996 | .9996 | .9996 | .9996 | .9996 | .9996 | .9997 |
| 3.4 | .9997 | .9997 | .9997 | .9997 | .9997 | .9997 | .9997 | .9997 | .9997 | .9998 |

| z | .00 | .01 | .02 | .03 | .04 | .05 | .06 | .07 | .08 | .09 |
|---|---|---|---|---|---|---|---|---|---|---|
| −3.4 | .0003 | .0003 | .0003 | .0003 | .0003 | .0003 | .0003 | .0003 | .0003 | .0002 |
| −3.3 | .0005 | .0005 | .0005 | .0004 | .0004 | .0004 | .0004 | .0004 | .0004 | .0003 |
| −3.2 | .0007 | .0007 | .0006 | .0006 | .0006 | .0006 | .0006 | .0005 | .0005 | .0005 |
| −3.1 | .0010 | .0009 | .0009 | .0009 | .0008 | .0008 | .0008 | .0008 | .0007 | .0007 |
| −3.0 | .0013 | .0013 | .0013 | .0012 | .0012 | .0011 | .0011 | .0011 | .0010 | .0010 |
| −2.9 | .0019 | .0018 | .0018 | .0017 | .0016 | .0016 | .0015 | .0015 | .0014 | .0014 |
| −2.8 | .0026 | .0025 | .0024 | .0023 | .0023 | .0022 | .0021 | .0021 | .0020 | .0019 |
| −2.7 | .0035 | .0034 | .0033 | .0032 | .0031 | .0030 | .0029 | .0028 | .0027 | .0026 |
| −2.6 | .0047 | .0045 | .0044 | .0043 | .0041 | .0040 | .0039 | .0038 | .0037 | .0036 |
| −2.5 | .0062 | .0060 | .0059 | .0057 | .0055 | .0054 | .0052 | .0051 | .0049 | .0048 |
| −2.4 | .0082 | .0080 | .0078 | .0075 | .0073 | .0071 | .0069 | .0068 | .0066 | .0064 |
| −2.3 | .0107 | .0104 | .0102 | .0099 | .0096 | .0094 | .0091 | .0089 | .0087 | .0084 |
| −2.2 | .0139 | .0136 | .0132 | .0129 | .0125 | .0122 | .0119 | .0116 | .0113 | .0110 |
| −2.1 | .0179 | .0174 | .0170 | .0166 | .0162 | .0158 | .0154 | .0150 | .0146 | .0143 |
| −2.0 | .0228 | .0222 | .0217 | .0212 | .0207 | .0202 | .0197 | .0192 | .0188 | .0183 |
| −1.9 | .0287 | .0281 | .0274 | .0268 | .0262 | .0256 | .0250 | .0244 | .0239 | .0233 |
| −1.8 | .0359 | .0351 | .0344 | .0336 | .0329 | .0322 | .0314 | .0307 | .0301 | .0294 |
| −1.7 | .0446 | .0436 | .0427 | .0418 | .0409 | .0401 | .0392 | .0384 | .0375 | .0367 |
| −1.6 | .0548 | .0537 | .0526 | .0516 | .0505 | .0495 | .0485 | .0475 | .0465 | .0455 |
| −1.5 | .0668 | .0655 | .0643 | .0630 | .0618 | .0606 | .0594 | .0582 | .0571 | .0559 |
| −1.4 | .0808 | .0793 | .0778 | .0764 | .0749 | .0735 | .0721 | .0708 | .0694 | .0681 |
| −1.3 | .0968 | .0951 | .0934 | .0918 | .0901 | .0885 | .0869 | .0853 | .0838 | .0823 |
| −1.2 | .1151 | .1131 | .1112 | .1093 | .1075 | .1056 | .1038 | .1020 | .1003 | .0985 |
| −1.1 | .1357 | .1335 | .1314 | .1292 | .1271 | .1251 | .1230 | .1210 | .1190 | .1170 |
| −1.0 | .1587 | .1562 | .1539 | .1515 | .1492 | .1469 | .1446 | .1423 | .1401 | .1379 |
| −0.9 | .1841 | .1814 | .1788 | .1762 | .1736 | .1711 | .1685 | .1660 | .1635 | .1611 |
| −0.8 | .2119 | .2090 | .2061 | .2033 | .2005 | .1977 | .1949 | .1922 | .1894 | .1867 |
| −0.7 | .2420 | .2389 | .2358 | .2327 | .2296 | .2266 | .2236 | .2206 | .2177 | .2148 |
| −0.6 | .2743 | .2709 | .2676 | .2643 | .2611 | .2578 | .2546 | .2514 | .2483 | .2451 |
| −0.5 | .3085 | .3050 | .3015 | .2981 | .2946 | .2912 | .2877 | .2843 | .2810 | .2776 |
| −0.4 | .3446 | .3409 | .3372 | .3336 | .3300 | .3264 | .3228 | .3192 | .3156 | .3121 |
| −0.3 | .3821 | .3783 | .3745 | .3707 | .3669 | .3632 | .3594 | .3557 | .3520 | .3483 |
| −0.2 | .4207 | .4168 | .4129 | .4090 | .4052 | .4013 | .3974 | .3936 | .3897 | .3859 |
| −0.1 | .4602 | .4562 | .4522 | .4483 | .4443 | .4404 | .4364 | .4325 | .4286 | .4247 |
| −0.0 | .5000 | .4960 | .4920 | .4880 | .4840 | .4801 | .4761 | .4721 | .4681 | .4641 |

# *t* Table

| cum. prob | $t_{.50}$ | $t_{.75}$ | $t_{.80}$ | $t_{.85}$ | $t_{.90}$ | $t_{.95}$ | $t_{.975}$ | $t_{.99}$ | $t_{.995}$ | $t_{.999}$ | $t_{.9995}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| one-tail | 0.50 | 0.25 | 0.20 | 0.15 | 0.10 | 0.05 | 0.025 | 0.01 | 0.005 | 0.001 | 0.0005 |
| two-tails | 1.00 | 0.50 | 0.40 | 0.30 | 0.20 | 0.10 | 0.05 | 0.02 | 0.01 | 0.002 | 0.001 |
| df | | | | | | | | | | | |
| 1 | 0.000 | 1.000 | 1.376 | 1.963 | 3.078 | 6.314 | 12.71 | 31.82 | 63.66 | 318.31 | 636.62 |
| 2 | 0.000 | 0.816 | 1.061 | 1.386 | 1.886 | 2.920 | 4.303 | 6.965 | 9.925 | 22.327 | 31.599 |
| 3 | 0.000 | 0.765 | 0.978 | 1.250 | 1.638 | 2.353 | 3.182 | 4.541 | 5.841 | 10.215 | 12.924 |
| 4 | 0.000 | 0.741 | 0.941 | 1.190 | 1.533 | 2.132 | 2.776 | 3.747 | 4.604 | 7.173 | 8.610 |
| 5 | 0.000 | 0.727 | 0.920 | 1.156 | 1.476 | 2.015 | 2.571 | 3.365 | 4.032 | 5.893 | 6.869 |
| 6 | 0.000 | 0.718 | 0.906 | 1.134 | 1.440 | 1.943 | 2.447 | 3.143 | 3.707 | 5.208 | 5.959 |
| 7 | 0.000 | 0.711 | 0.896 | 1.119 | 1.415 | 1.895 | 2.365 | 2.998 | 3.499 | 4.785 | 5.408 |
| 8 | 0.000 | 0.706 | 0.889 | 1.108 | 1.397 | 1.860 | 2.306 | 2.896 | 3.355 | 4.501 | 5.041 |
| 9 | 0.000 | 0.703 | 0.883 | 1.100 | 1.383 | 1.833 | 2.262 | 2.821 | 3.250 | 4.297 | 4.781 |
| 10 | 0.000 | 0.700 | 0.879 | 1.093 | 1.372 | 1.812 | 2.228 | 2.764 | 3.169 | 4.144 | 4.587 |
| 11 | 0.000 | 0.697 | 0.876 | 1.088 | 1.363 | 1.796 | 2.201 | 2.718 | 3.106 | 4.025 | 4.437 |
| 12 | 0.000 | 0.695 | 0.873 | 1.083 | 1.356 | 1.782 | 2.179 | 2.681 | 3.055 | 3.930 | 4.318 |
| 13 | 0.000 | 0.694 | 0.870 | 1.079 | 1.350 | 1.771 | 2.160 | 2.650 | 3.012 | 3.852 | 4.221 |
| 14 | 0.000 | 0.692 | 0.868 | 1.076 | 1.345 | 1.761 | 2.145 | 2.624 | 2.977 | 3.787 | 4.140 |
| 15 | 0.000 | 0.691 | 0.866 | 1.074 | 1.341 | 1.753 | 2.131 | 2.602 | 2.947 | 3.733 | 4.073 |
| 16 | 0.000 | 0.690 | 0.865 | 1.071 | 1.337 | 1.746 | 2.120 | 2.583 | 2.921 | 3.686 | 4.015 |
| 17 | 0.000 | 0.689 | 0.863 | 1.069 | 1.333 | 1.740 | 2.110 | 2.567 | 2.898 | 3.646 | 3.965 |
| 18 | 0.000 | 0.688 | 0.862 | 1.067 | 1.330 | 1.734 | 2.101 | 2.552 | 2.878 | 3.610 | 3.922 |
| 19 | 0.000 | 0.688 | 0.861 | 1.066 | 1.328 | 1.729 | 2.093 | 2.539 | 2.861 | 3.579 | 3.883 |
| 20 | 0.000 | 0.687 | 0.860 | 1.064 | 1.325 | 1.725 | 2.086 | 2.528 | 2.845 | 3.552 | 3.850 |
| 21 | 0.000 | 0.686 | 0.859 | 1.063 | 1.323 | 1.721 | 2.080 | 2.518 | 2.831 | 3.527 | 3.819 |
| 22 | 0.000 | 0.686 | 0.858 | 1.061 | 1.321 | 1.717 | 2.074 | 2.508 | 2.819 | 3.505 | 3.792 |
| 23 | 0.000 | 0.685 | 0.858 | 1.060 | 1.319 | 1.714 | 2.069 | 2.500 | 2.807 | 3.485 | 3.768 |
| 24 | 0.000 | 0.685 | 0.857 | 1.059 | 1.318 | 1.711 | 2.064 | 2.492 | 2.797 | 3.467 | 3.745 |
| 25 | 0.000 | 0.684 | 0.856 | 1.058 | 1.316 | 1.708 | 2.060 | 2.485 | 2.787 | 3.450 | 3.725 |
| 26 | 0.000 | 0.684 | 0.856 | 1.058 | 1.315 | 1.706 | 2.056 | 2.479 | 2.779 | 3.435 | 3.707 |
| 27 | 0.000 | 0.684 | 0.855 | 1.057 | 1.314 | 1.703 | 2.052 | 2.473 | 2.771 | 3.421 | 3.690 |
| 28 | 0.000 | 0.683 | 0.855 | 1.056 | 1.313 | 1.701 | 2.048 | 2.467 | 2.763 | 3.408 | 3.674 |
| 29 | 0.000 | 0.683 | 0.854 | 1.055 | 1.311 | 1.699 | 2.045 | 2.462 | 2.756 | 3.396 | 3.659 |
| 30 | 0.000 | 0.683 | 0.854 | 1.055 | 1.310 | 1.697 | 2.042 | 2.457 | 2.750 | 3.385 | 3.646 |
| 40 | 0.000 | 0.681 | 0.851 | 1.050 | 1.303 | 1.684 | 2.021 | 2.423 | 2.704 | 3.307 | 3.551 |
| 60 | 0.000 | 0.679 | 0.848 | 1.045 | 1.296 | 1.671 | 2.000 | 2.390 | 2.660 | 3.232 | 3.460 |
| 80 | 0.000 | 0.678 | 0.846 | 1.043 | 1.292 | 1.664 | 1.990 | 2.374 | 2.639 | 3.195 | 3.416 |
| 100 | 0.000 | 0.677 | 0.845 | 1.042 | 1.290 | 1.660 | 1.984 | 2.364 | 2.626 | 3.174 | 3.390 |
| 1000 | 0.000 | 0.675 | 0.842 | 1.037 | 1.282 | 1.646 | 1.962 | 2.330 | 2.581 | 3.098 | 3.300 |
| *z* | 0.000 | 0.674 | 0.842 | 1.036 | 1.282 | 1.645 | 1.960 | 2.326 | 2.576 | 3.090 | 3.291 |
| | 0% | 50% | 60% | 70% | 80% | 90% | 95% | 98% | 99% | 99.8% | 99.9% |
| | Confidence Level | | | | | | | | | | |