STA 113 Name:______________________________

**Probability and Statistics in Engineering: Second Test**

2:15-3:30 pm Thursday, April 3, 1997

This is a **closed-book** examination, so please do not refer to your notes, the text, or to any other books. A few pages of formulas, tables, and blank worksheets are appended to the exam. Please do not use your own scratch paper; you may use your own calculator but may not share one. Each problem counts the same (20 points), but they may not seem equally long or equally difficult. Please **DON'T** spend time redoing calculations already done for you (e.g. sample means & variances). As usual, pictures (sketches, plots, etc.) are helpful for most problems.

Please ask me to explain anything you don't understand in the questions (wording, definitions, *etc.*). It is to your advantage to write your solutions as clearly as possible, and to show enough of your work to make clear how you got your answer (especially important if you used a calculator in some key step)—even correct answers may be awarded little or **no credit** without a clear explanation of your method. Good luck! Please sign the Duke Honor Code:

**I have neither given nor received aid on this examination.**

______________________________

*signature*

| | |
|---|---|
| 1. | /20 |
| 2. | /20 |
| 3. | /20 |
| 4. | /20 |
| 5. | /20 |
| | /100 |

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## Probability and Statistics in Engineering: Second Test

1. A candy company distributes boxes of chocolates with a mixture of creams, toffees, and cordials. Suppose that the weight of each box is 1 kilogram, but the individual weights of the creams, toffees, and cordials vary from box to box. For a randomly selected box, let $X$ and $Y$ represent the weights of the creams and toffees, respectively, and suppose that the joint density function of these variables is given by

$$f(x, y) = \begin{cases} 24xy, & 0 \le x \le 1,\ 0 \le y \le 1,\ x + y \le 1 \\ 0, & \text{elsewhere.} \end{cases}$$

a. (5pt) Find the probability that in a given box each of creams and toffees constitutes less than 1/2 of the weight.

$\mathsf{P}[X < 1/2, Y < 1/2] =$ ____________

b. (5pt) Find the marginal density for the weight of the creams. Be sure your answer is correct for *all* values of $x$.

$f_1(x) =$ ____________

c. (5pt) Find the probability that the weight of the toffees in a box is less than 1/8 kg. if it is known that the creams constitute 3/4 of the weight.

$\mathsf{P}[\qquad \mid \qquad] =$ ____________

d. (5pt) Are $X$ and $Y$ independent? Why?

Circle one: Yes No Reasoning:

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2. Nine subjects were used in an experiment to determine if an atmosphere involving exposure to carbon monoxide has an impact on breathing capability. Subjects were exposed to breathing chambers, one of which contained a high concentration of CO. Several breathing measures were made for each subject for each chamber. The subjects were exposed to the breathing chambers in a random sequence. The following data give the breathing frequency (in breaths taken per minute) and oxygen intake (ml/kg/min), with and without CO:

| **Subj** | **Breathing Rate** | | | **Oxygen Intake** | | |
|---|---|---|---|---|---|---|
| | w/CO | No CO | $\Delta$ | w/CO | No CO | $\Delta$ |
| 1 | 30 | 30 | 0 | 26.46 | 25.41 | 1.05 |
| 2 | 45 | 40 | 5 | 17.46 | 22.53 | −5.07 |
| 3 | 26 | 25 | 1 | 16.32 | 16.32 | 0.00 |
| 4 | 25 | 23 | 2 | 20.19 | 27.48 | −7.29 |
| 5 | 34 | 30 | 4 | 19.84 | 24.97 | −5.13 |
| 6 | 51 | 49 | 2 | 20.65 | 21.77 | −1.12 |
| 7 | 46 | 41 | 5 | 28.21 | 28.17 | 0.04 |
| 8 | 32 | 35 | −3 | 33.94 | 32.02 | 1.92 |
| 9 | 30 | 28 | 2 | 29.32 | 28.96 | 0.36 |
| $\bar{Y}$ | 35.44 | 33.44 | 2.0 | 23.60 | 25.29 | −1.69 |
| $s^2$ | 89.52 | 72.28 | 6.5 | 36.78 | 21.55 | 10.69 |

a. (10pt) It is conjectured that oxygen consumption should be higher in an environment relatively free of CO. Do an hypothesis test and discuss this conjecture.

b. (10pt) Make a one-sided test of the hypothesis that mean breathing frequency is the same for the two environments. Use $\alpha = 0.05$.

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3. A machine produces metal pieces that are cylindrical in shape. A sample of pieces is taken and the diameters are 1.01, 0.97, 1.03, 1.04, 0.99, 0.98, 0.99, 1.01, and 1.03 centimeters (the sample mean of these $n = 9$ observations is $\bar{Y} = 1.0056$; sample variance is $s^2 = 0.0006028 = (0.02455)^2$).

a. (15pt) Find a 99% confidence interval for the (population) mean diameter of pieces from this machine, assuming an approximately normal population distribution.

b. (5pt) Test the hypothesis $H_0 : \mu = 1.0$ against the one-sided alternative $H_a : \mu > 1$. Give the correct decision (reject or accept $H_0$) at level $\alpha = .01$ and, if possible, give the approximate $p-$value (a range is okay).

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4. (20pt) A random sample of size $n_1 = 25$, taken from a normal population with a standard deviation $\sigma_1 = 5$, has mean $\bar{x}_1 = 80$. A random sample of size $n_2 = 36$, taken from another normal population with a standard deviation $\sigma_2 = 3$, has mean $\bar{x}_2 = 75$. Find a 95% confidence interval for the difference in means $\Delta = [\mu_1 - \mu_2]$. If you feel additional assumptions are necessary, please state them clearly.

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5. Mark the best answer for each of parts a–d (5pt each):

a. Why do we sometimes use the $t$ distribution with some number $\nu$ of degrees of freedom, instead of the normal distribution?

- ☐ Because we're not sure if the population distribution is normal or not.
- ☐ Because we don't know the population variance $\sigma^2$ and must estimate it from the sample by $s^2$.
- ☐ Because the population variances $\sigma_1^2$ and $\sigma_2^2$ might not be the same.

b. When do we use "paired-$t$" hypothesis tests and confidence intervals?

- ☐ When we have two populations, both normally distributed, but maybe with different variances.
- ☐ When we have two samples with the same sample size.
- ☐ When we have observations for both populations from each of several experimental subjects, and want to minimize the effect of variations among the subjects.

c. If we estimate a normal mean by $\mu = \bar{Y} \pm 2.326\,\sigma/\sqrt{n}$, what is the (approximate) probability that the interval we find will contain $\mu$?

| | | | |
|---|---|---|---|
| ☐ 80% | ☐ 90% | ☐ 95% | ☐ 97.5% |
| ☐ 98% | ☐ 99% | ☐ 99.8% | ☐ 99.9% |

d. In a test of the null hypothesis $H_0 : \mu = 0$ with a normally distributed population we find $z = \frac{\bar{X}}{\sigma/\sqrt{n}} = 2.0$. Give the $p-$value and decision (accept or reject) for each of the following alternatives, using level $\alpha = .04$.

| | | | |
|---|---|---|---|
| $H_a : \mu \neq 0$ | ☐ Reject $H_0$ | ☐ Can't reject $H_0$ | $P =$ ________ |
| $H_a : \mu > 0$ | ☐ Reject $H_0$ | ☐ Can't reject $H_0$ | $P =$ ________ |
| $H_a : \mu < 0$ | ☐ Reject $H_0$ | ☐ Can't reject $H_0$ | $P =$ ________ |

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## Probability and Statistics in Engineering: Second Test

### Distributions

| | | | |
|---|---|---|---|
| Bernoulli | $\Pr[X=x]=p^x q^{1-x},\ x=0,1$ | $\mu=p,$ | $\sigma^2=pq$ |
| Binomial | $\Pr[X=x]=\binom{n}{x}p^x q^{n-x},\ x=0,1,\ldots,n$ | $\mu=np,$ | $\sigma^2=npq$ |
| Poisson | $\Pr[X=x]=\lambda^x e^{-\lambda}/x!,\ x=0,1,\ldots$ | $\mu=\lambda,$ | $\sigma^2=\lambda$ |
| Geometric | $\Pr[X=x]=pq^{x-1},\ x=1,2,\ldots$ | $\mu=1/p,$ | $\sigma^2=q/p^2$ |
| Neg. Binomial | $\Pr[X=x]=\binom{x-1}{r-1}p^r q^{x-r},\ x=r,r+1,\ldots$ | $\mu=r/p,$ | $\sigma^2=rq/p^2$ |
| Hypergeometric | $\Pr[X=x]=\dfrac{\binom{r}{x}\binom{N-r}{n-x}}{\binom{N}{n}},\ x=0,1,\ldots,n$ | $\mu=\dfrac{nr}{N},$ | $\sigma^2=$ a mess |
| Exponential | $\Pr[X\le x]=1-e^{-x/\beta},\ x\in(0,\infty)$ | $\mu=\beta,$ | $\sigma^2=\beta^2$ |
| | $f(x)=\dfrac{1}{\beta}e^{-x/\beta},\ x>0;\ 0,\ x\le 0$ | | |
| Gamma | $\Pr[X\le x]=1-e^{-x/\beta}\sum_{k=0}^{\alpha-1}(x/\beta)^k/k!,\ x>0$ | $\mu=\alpha\beta,$ | $\sigma^2=\alpha\beta^2$ |
| | $f(x)=\dfrac{x^{\alpha-1}}{\beta^\alpha\,\Gamma(\alpha)}e^{-x/\beta},\ x>0;\ 0,\ x\le 0$ | | |
| Uniform | $\Pr[X\le x]=(x-a)/(b-a),\ x\in(a,b)$ | $\mu=\dfrac{a+b}{2},$ | $\sigma^2=\dfrac{(b-a)^2}{12}$ |
| | $f(x)=\dfrac{1}{b-a},\ a<x<b;\ 0,\ x\notin(a,b)$ | | |
| Normal | $\Pr[X\le x]=\Phi(\dfrac{x-\mu}{\sigma})=\begin{cases}.5+A(\frac{\lvert x-\mu\rvert}{\sigma}) & \text{if } x>\mu\\ .5-A(\frac{\lvert x-\mu\rvert}{\sigma}) & \text{if } x<\mu\end{cases}$ | (See Table 4) | |
| | $\phi(x)=\dfrac{1}{\sigma\sqrt{2\pi}}e^{-(x-\mu)^2/2\sigma^2}$ | | |

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$\sum_{k=0}^{n}\binom{n}{k}a^k b^{n-k}=(a+b)^n$ $\qquad$ $\int_0^\infty t^{n-1}e^{-t}\,dt=\Gamma(n)=(n-1)!$

$\sum_{k=0}^{\infty}ar^k=a/(1-r)$ $\qquad$ $\sum_{k=0}^{n}ar^k=(a-ar^{n+1})/(1-r)$

$\sum_{k=0}^{\infty}x^k/k!=e^x$ $\qquad$ $\sum_{k=0}^{n}k=n(n+1)/2$

$A$ **and** $B$: $A\cap B$ $\qquad$ **not** $A$: $A^c$ $\qquad$ $A$ **or** $B$: $A\cup B$

$\mathsf{P}[A|B]=\mathsf{P}[A\cap B]/\mathsf{P}[B]$ $\qquad$ $\mathsf{P}[B|A]=\mathsf{P}[A\cap B]/\mathsf{P}[A]$

$\mathsf{P}[A\cap B]=\mathsf{P}[A|B]\,\mathsf{P}[B]$ $\qquad$ $\mathsf{P}[A\cup B]=\mathsf{P}[A]+\mathsf{P}[B]-\mathsf{P}[A\cap B]$

Independent $\Leftrightarrow \mathsf{P}[A\cap B]=\mathsf{P}[A]\,\mathsf{P}[B]$; Exclusive $\Leftrightarrow \mathsf{P}[A\cap B]=0$

Bayes: $\mathsf{P}[A_i|B]=\frac{\mathsf{P}[B|A_i]\mathsf{P}[A_i]}{\mathsf{P}[B|A_1]\mathsf{P}[A_1]+\ldots+\mathsf{P}[B|A_k]\mathsf{P}[A_k]}$ $A_i\cap A_j=\emptyset,\quad \mathsf{P}[A_1]+\ldots+\mathsf{P}[A_k]=1$

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| | Continuous | Discrete |
|---|---|---|
| CDF | $F(x) = \int_{-\infty}^{x} f(t)dt$ | $= \sum_{t \le x} p(t)$ |
| pdf, pmf | $f(x) = F'(x)$ | $p(x) = F(x) - F(x-)$ |
| Mean | $\mu = \mathsf{E}[X] = \int_{-\infty}^{\infty} x\, f(x)dx$ | $= \sum xp(x)$ |
| Variance | $\sigma^2 = \mathsf{V}[X] = \mathsf{E}[(X-\mu)^2] = \mathsf{E}[X^2] - \mathsf{E}[X]^2$ | $= \mathsf{E}[(X-\mu)^2] = \mathsf{E}[X^2] - \mathsf{E}[X]^2$ |
| | $= \int_{-\infty}^{\infty} (x-\mu)^2\, f(x)dx$ | $= \sum (x-\mu)^2 p(x)$ |
| Expectation | $\mathsf{E}[g(X)] = \int_{-\infty}^{\infty} g(x)\, f(x)dx$ | $= \sum_x g(x)\, p(x)$ |
| | $\mathsf{E}[g(X,Y)] = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} g(x,y)\, f(x,y)dx\, dy$ | $= \sum_x \sum_y g(x,y)\, p(x,y)$ |
| Covariance | $\mathsf{Cov}[X,Y] = \mathsf{E}[(X-\mu_x)(Y-\mu_y)]$ | $= \mathsf{E}[(X-\mu_x)(Y-\mu_y)]$ |
| | $= \mathsf{E}[XY] - \mathsf{E}[X]\mathsf{E}[Y]$ | $= \mathsf{E}[XY] - \mathsf{E}[X]\mathsf{E}[Y]$ |
| | $= \iint_{-\infty,-\infty}^{\infty,\infty} (x-\mu_x)(y-\mu_y)\, f(x,y)dx\, dy$ | $= \sum_x \sum_y (x-\mu_x)(y-\mu_y)\, p(x,y)$ |
| Correlation | $\rho[X,Y] = \mathsf{Cov}[X,Y]/\sigma_X\sigma_Y$ | |
| Conditional | $f_1(x\|y) = f(x,y)/f_2(y)$ | $p_1(x\|y) = p(x,y)/p_2(y)$ |
| Marginals | $f_1(x) = \int_{-\infty}^{\infty} f(x,y)dy$ | $p_1(x) = \sum_y p(x,y)$ |
| | $f_2(y) = \int_{-\infty}^{\infty} f(x,y)dx$ | $p_2(y) = \sum_x p(x,y)$ |
| Independent | $\Leftrightarrow f(x,y) = f_1(x)\, f_2(y)$ | $\Leftrightarrow p(x,y) = p_1(x)\, p_2(y)$ |
| | $\Leftrightarrow f_1(x\|y) = f_1(x)$ | $\Leftrightarrow p_1(x\|y) = p_1(x)$ |
| | $\Leftrightarrow f_2(y\|x) = f_2(y)$ | $\Leftrightarrow p_2(y\|x) = p_2(y)$ |

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| | | |
|---|---|---|
| Conf. Intervals | $\mu = \bar{x} \pm z_{\alpha/2} S/\sqrt{n}$ | Large Sample |
| | $= \bar{x} \pm t_{\alpha/2} S/\sqrt{n}$ | Small Sample (normal) |
| | $p = \hat{p} \pm z_{\alpha/2}\sqrt{\hat{p}\,\hat{q}/n}$ | Population Proportion |
| Diff. of Means | $\mu_1 - \mu_2 = (\bar{x}_1 - \bar{x}_2) \pm z_{\alpha/2}\sqrt{s_1^2/n_1 + s_2^2/n_2}$ | Large Samples |
| | $= (\bar{x}_1 - \bar{x}_2) \pm t_{\alpha/2} s_p \sqrt{1/n_1 + 1/n_2}$ | Small Samples (normal, same $\sigma^2$) |
| | $= \overline{x_1 - x_2} \pm z_{\alpha/2} s_\Delta/\sqrt{n}$ | Matched Pairs, large $n$ |
| | $= \overline{x_1 - x_2} \pm t_{\alpha/2} s_\Delta/\sqrt{n}$ | Matched Pairs, small $n$, normal |
| Sample Mean, Var | $\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$ | $s^2 = \frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2$ |
| Pooled Var. Estimate | $s_p^2 = \frac{(n_1-1)s_1^2 + (n_2-1)s_2^2}{n_1+n_2-2}$ | $\nu = n_1 + n_2 - 2$ |

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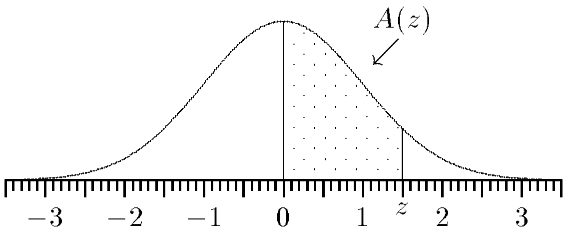
### TABLE 4 Normal Curve Areas

$$A(z) = \int_0^z \frac{1}{\sqrt{2\pi}} e^{-t^2/2}\, dt:$$




| z | .00 | .01 | .02 | .03 | .04 | .05 | .06 | .07 | .08 | .09 |
|---|---|---|---|---|---|---|---|---|---|---|
| .0 | .0000 | .0040 | .0080 | .0120 | .0160 | .0199 | .0239 | .0279 | .0319 | .0359 |
| .1 | .0398 | .0438 | .0478 | .0517 | .0557 | .0596 | .0636 | .0675 | .0714 | .0753 |
| .2 | .0793 | .0832 | .0871 | .0910 | .0948 | .0987 | .1026 | .1064 | .1103 | .1141 |
| .3 | .1179 | .1217 | .1255 | .1293 | .1331 | .1368 | .1406 | .1443 | .1480 | .1517 |
| .4 | .1554 | .1591 | .1628 | .1664 | .1700 | .1736 | .1772 | .1808 | .1844 | .1879 |
| .5 | .1915 | .1950 | .1985 | .2019 | .2054 | .2088 | .2123 | .2157 | .2190 | .2224 |
| .6 | .2257 | .2291 | .2324 | .2357 | .2389 | .2422 | .2454 | .2486 | .2517 | .2549 |
| .7 | .2580 | .2611 | .2642 | .2673 | .2704 | .2734 | .2764 | .2794 | .2823 | .2852 |
| .8 | .2881 | .2910 | .2939 | .2967 | .2995 | .3023 | .3051 | .3078 | .3106 | .3133 |
| .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 |

### TABLE 7 Critical Values

$A(1.282) = 0.4000$ $A(1.645) = 0.4500$ $A(1.960) = 0.4750$ $A(2.326) = 0.4900$

$A(2.576) = 0.4950$ $A(3.090) = 0.4990$ $A(3.291) = 0.4995$ $A(3.719) = 0.4999$

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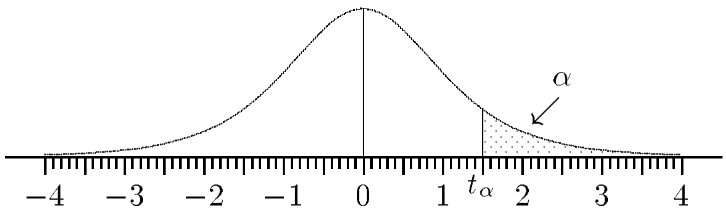
**TABLE 7** **Critical Values for Student's $t$**

$$\alpha = \int_{t_\alpha}^{\infty} \frac{c\, dt}{(1 + t^2/\nu)^{(\nu+1)/2}}$$




| $\nu$ | $t_{.40}$ | $t_{.30}$ | $t_{.20}$ | $t_{.10}$ | $t_{.05}$ | $t_{.025}$ | $t_{.01}$ | $t_{.005}$ | $t_{.001}$ | $t_{.0005}$ | $t_{.0001}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.325 | 0.727 | 1.376 | 3.078 | 6.314 | 12.76 | 31.82 | 63.66 | 318.3 | 636.6 | 3183. |
| 2 | 0.289 | 0.617 | 1.061 | 1.886 | 2.920 | 4.303 | 6.965 | 9.925 | 22.33 | 31.60 | 70.70 |
| 3 | 0.277 | 0.584 | 0.978 | 1.638 | 2.353 | 3.182 | 4.541 | 5.841 | 10.22 | 12.92 | 22.20 |
| 4 | 0.271 | 0.569 | 0.941 | 1.533 | 2.132 | 2.776 | 3.747 | 4.604 | 7.173 | 8.610 | 13.03 |
| 5 | 0.267 | 0.559 | 0.920 | 1.476 | 2.015 | 2.571 | 3.365 | 4.032 | 5.893 | 6.869 | 9.678 |
| 6 | 0.265 | 0.553 | 0.906 | 1.440 | 1.943 | 2.447 | 3.143 | 3.707 | 5.208 | 5.959 | 8.025 |
| 7 | 0.263 | 0.549 | 0.896 | 1.415 | 1.895 | 2.365 | 2.998 | 3.499 | 4.785 | 5.408 | 7.063 |
| 8 | 0.262 | 0.546 | 0.889 | 1.397 | 1.860 | 2.306 | 2.896 | 3.355 | 4.501 | 5.041 | 6.442 |
| 9 | 0.261 | 0.543 | 0.883 | 1.383 | 1.833 | 2.262 | 2.821 | 3.250 | 4.297 | 4.781 | 6.010 |
| 10 | 0.260 | 0.542 | 0.879 | 1.372 | 1.812 | 2.228 | 2.764 | 3.169 | 4.144 | 4.587 | 5.694 |
| 11 | 0.260 | 0.540 | 0.876 | 1.363 | 1.796 | 2.201 | 2.718 | 3.106 | 4.025 | 4.437 | 5.453 |
| 12 | 0.259 | 0.539 | 0.873 | 1.356 | 1.782 | 2.179 | 2.681 | 3.055 | 3.930 | 4.318 | 5.263 |
| 13 | 0.259 | 0.538 | 0.870 | 1.350 | 1.771 | 2.160 | 2.650 | 3.012 | 3.852 | 4.221 | 5.111 |
| 14 | 0.258 | 0.537 | 0.868 | 1.345 | 1.761 | 2.145 | 2.624 | 2.977 | 3.787 | 4.140 | 4.985 |
| 15 | 0.258 | 0.536 | 0.866 | 1.341 | 1.753 | 2.131 | 2.602 | 2.947 | 3.733 | 4.073 | 4.880 |
| 16 | 0.258 | 0.535 | 0.865 | 1.337 | 1.746 | 2.120 | 2.583 | 2.921 | 3.686 | 4.015 | 4.791 |
| 17 | 0.257 | 0.534 | 0.863 | 1.333 | 1.740 | 2.110 | 2.567 | 2.898 | 3.646 | 3.965 | 4.714 |
| 18 | 0.257 | 0.534 | 0.862 | 1.330 | 1.734 | 2.101 | 2.552 | 2.878 | 3.610 | 3.922 | 4.648 |
| 19 | 0.257 | 0.533 | 0.861 | 1.328 | 1.729 | 2.093 | 2.539 | 2.861 | 3.579 | 3.883 | 4.590 |
| 20 | 0.257 | 0.533 | 0.860 | 1.325 | 1.725 | 2.086 | 2.528 | 2.845 | 3.552 | 3.85 | 4.539 |
| 21 | 0.257 | 0.532 | 0.859 | 1.323 | 1.721 | 2.080 | 2.518 | 2.831 | 3.527 | 3.819 | 4.493 |
| 22 | 0.256 | 0.532 | 0.858 | 1.321 | 1.717 | 2.074 | 2.508 | 2.819 | 3.505 | 3.792 | 4.452 |
| 23 | 0.256 | 0.532 | 0.858 | 1.319 | 1.714 | 2.069 | 2.500 | 2.807 | 3.485 | 3.768 | 4.415 |
| 24 | 0.256 | 0.531 | 0.857 | 1.318 | 1.711 | 2.064 | 2.492 | 2.797 | 3.467 | 3.745 | 4.382 |
| 25 | 0.256 | 0.531 | 0.856 | 1.316 | 1.708 | 2.060 | 2.485 | 2.787 | 3.450 | 3.725 | 4.352 |
| 26 | 0.256 | 0.531 | 0.856 | 1.315 | 1.706 | 2.056 | 2.479 | 2.779 | 3.435 | 3.707 | 4.324 |
| 27 | 0.256 | 0.531 | 0.855 | 1.314 | 1.703 | 2.052 | 2.473 | 2.771 | 3.421 | 3.690 | 4.299 |
| 28 | 0.256 | 0.530 | 0.855 | 1.313 | 1.701 | 2.048 | 2.467 | 2.763 | 3.408 | 3.674 | 4.275 |
| 29 | 0.256 | 0.530 | 0.854 | 1.311 | 1.699 | 2.045 | 2.462 | 2.756 | 3.396 | 3.659 | 4.254 |
| 30 | 0.256 | 0.530 | 0.854 | 1.310 | 1.697 | 2.042 | 2.457 | 2.750 | 3.385 | 3.646 | 4.234 |
| 40 | 0.255 | 0.529 | 0.851 | 1.303 | 1.684 | 2.021 | 2.423 | 2.704 | 3.307 | 3.551 | 4.094 |
| 60 | 0.254 | 0.527 | 0.848 | 1.296 | 1.671 | 2.000 | 2.390 | 2.660 | 3.232 | 3.460 | 3.962 |
| 120 | 0.254 | 0.526 | 0.845 | 1.289 | 1.658 | 1.980 | 2.358 | 2.617 | 3.160 | 3.373 | 3.837 |
| $\infty$ | 0.253 | 0.524 | 0.842 | 1.282 | 1.645 | 1.960 | 2.326 | 2.576 | 3.090 | 3.291 | 3.719 |

STA 113 Name: ______________________________

**Probability and Statistics in Engineering: Second Test**

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STA 113 Name: ______________________________

**Probability and Statistics in Engineering: Second Test**

(Nearly) Blank Work-Sheet #2 (of 2)