

科目名稱	統計學	類組代碼	B11.B12.D38
		科目碼	B1192

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每題 4 分，共 100 分

I. Diagnostic Testing & Bayes' Theorem

1. A disease affects 2% of a population. A diagnostic test has a sensitivity of 95% and a specificity of 90%. If a person tests positive, what is the probability that the person actually has the disease?

- A. 0.16
- B. 0.50
- C. 0.80
- D. 0.95

II. Linear Regression

2. In a multiple linear regression analysis, if two or more predictor variables are highly correlated (multicollinearity), what is the direct consequence on the ordinary least squares (OLS) parameter estimates?

- A. The estimates become highly biased away from their true population values.
- B. The variances and standard errors of the estimated coefficients inflate dramatically.
- C. The residual sum of squares (SSE) drops automatically to zero.
- D. The model's overall R^2 value drops significantly and approaches negative infinity.

III. Linear Regression

Consider the following data for independent variable x and dependent variable y :

x	1	2	3	4	5
y	12	11	8	6	3

Table 1 — Standardized Residuals and Leverage Values

x	y	$\hat{y}$	Residual (e)	Leverage (h_i)	Standardized Residual
1	12	12.2	-0.2	0.60	-0.25
2	11	10.0	1.0	0.30	(1)
3	8	7.8	0.2	0.20	0.27
4	6	5.6	0.4	0.30	0.59
5	3	3.4	-0.4	0.60	-0.50

3. What is the total sum of squares (SST) for this data set?

- A. 10
- B. 30
- C. 45
- D. 50

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4. What is the coefficient of determination, R^2 , for this regression model?

A. 0.80
B. 0.86
C. 0.90
D. 0.96

5. What is the leverage value in (1) in Table 1?

A. 0.27
B. -1.27
C. 1.47
D. 1.27

6. What is the estimate of the slope in the simple linear regression model for this data?

A. 1.5
B. 2.3
C. -1.4
D. -2.5

IV. Two-Way ANOVA & Experimental Design

An industrial statistics experiment involves two types of coating material (Factor A, 2 levels) and three curing temperatures (Factor B, 3 levels). The response variable is the adhesion strength of the coating. Two replicates ($n = 2$) were tested for each treatment combination, resulting in the following data layout:

Factor A (Coating)	Factor B – Temp. Level 1	Factor B – Temp. Level 2	Factor B – Temp. Level 3
Level 1	10, 12	14, 16	18, 20
Level 2	12, 14	18, 20	24, 26

The ANOVA table for this data is:

Source of Variation	SS	df	MS	F
Factor A (Coating)	48.00	1	48.00	24.00
Factor B (Temperature)		2		50.00
Interaction (A × B)	8.00		4.00	
Error (Within-Cell)		6		—
Total	268.00	11	—	—

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7. In a two-way ANOVA layout, the total proportion of variance explained by the model (main effects plus interaction) can be evaluated similarly to R^2 in regression. Based on the ANOVA table above, what proportion of the total variation in adhesion strength is unexplained by the factors and their interaction?

- A. 4.48%
- B. 7.46%
- C. 92.54%
- D. 95.52%

8. Assuming a fixed-effects model (with the usual constraint that the effects sum to zero), the expected value of the Mean Square Error equals the true error variance, σ^2 . Based on the ANOVA table, what is the unbiased point estimate of σ^2 for this manufacturing process?

- A. 1.00
- B. 2.00
- C. 4.00
- D. 12.00

9. The interaction effect measures the non-additivity of the model. If the main effects were completely additive, the difference between Temperature Level 3 and Level 1 would be identical for both Coating levels. Calculate the component of the Sum of Squares attributed purely to the Interaction (Coating $\times$ Temperature).

- A. 4.00
- B. 8.00
- C. 16.00
- D. 24.00

10. To test the null hypothesis that there is no interaction effect (H_0), the test statistic follows a central F-distribution under H_0 . Comparing the observed F-statistic ($F = 2.00$, from the ANOVA table) to the critical value at $\alpha = 0.05$, which statement correctly captures the statistical decision regarding the interaction?

- A. Reject H_0 ; there is an explicit, statistically significant joint synergistic effect.
- B. Fail to reject H_0 ; the interaction profile indicates parallel response tendencies across levels.
- C. Reject H_0 ; the interaction dominates the variance budget over the main effects.
- D. Fail to reject H_0 ; the cell means show a purely horizontal linear trend.

11. Because Factor B (Temperature) has three levels and is highly significant, an analyst wants to perform a post-hoc pairwise comparison between the marginal means of Temperature Level 1 and Temperature Level 3. Using the appropriate critical value from the two-tailed Student's t-distribution at $\alpha = 0.05$ with the error degrees of freedom from the ANOVA table, calculate Fisher's Least Significant Difference (LSD) for comparing two marginal means of Factor B.

- A. 1.41
- B. 2.45
- C. 3.46
- D. 4.90

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V. Measures of Dispersion

12. The hourly wages of a sample of 130 systems analysts have a mean of 60, a mode of 73, a median of 74, a range of 20, and a variance of 324. What is the coefficient of variation?

A. 0.30%
 B. 30%
 C. 5.4%
 D. 54%

VI. Joint & Conditional Probability

A survey of business students recorded the gender of each individual and their selected major:

Gender	Management	Marketing	Others	Total
Male	60	36	24	120
Female	40	24	16	80
Total	100	60	40	200

13. What is the probability of selecting an individual who is majoring in Management?

A. 0.5
 B. 0.4
 C. 0.3
 D. 0.2

14. What is the probability of selecting an individual who is majoring in Marketing, given that the person is male?

A. 0.5
 B. 0.4
 C. 0.3
 D. 0.2

15. What is the probability that a person is female, given that the individual's major is Marketing?

A. 0.5
 B. 0.4
 C. 0.3
 D. 0.2

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VII. Discrete Probability DistributionsThe probability distribution $P(x)$ of a discrete random variable x is shown below:

x	1	2	3	4	5
P(x)	0.1	0.2	0.4	0.2	0.1

16. Find the expected value of x .

- A. 1
- B. 2
- C. 3
- D. 4

17. Find the variance of x .

- A. 1.0
- B. 1.2
- C. 1.5
- D. 2.0

18. Find the coefficient of variation of x .

- A. 22.5%
- B. 36.5%
- C. 40.5%
- D. 42.5%

VIII. Chebyshev's Theorem

In a statistics class, the average grade on the final exam was 50 with a standard deviation of 10. Use Chebyshev's theorem to answer the following:

19. At least what percentage of students received grades between 35 and 65?

- A. 0.56
- B. 0.60
- C. 0.70
- D. 0.72

20. Determine an interval for the grades that will be true for at least 75% of the students.

- A. (20, 60)
- B. (30, 60)
- C. (25, 65)
- D. (30, 70)

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IX. The Normal Distribution			
A professor at a local community college noted that the grades of his students were normally distributed with a mean of 60 and a standard deviation of 10. Ten percent of his students received A's, and only 10 percent of his students failed the course and received F's.			
21. What is the minimum score needed to make an A?			
A. 70			
B. 73			
C. 78			
D. 80			
22. If 10 students did not pass the course, how many students took the course in total?			
A. 50			
B. 100			
C. 150			
D. 200			
X. Sampling Distributions			
A department store has determined that 60% of all their sales are credit sales. A random sample of 36 sales is selected.			
23. What is the probability that the sample proportion will be between 0.60 and 0.80?			
A. 0.27			
B. 0.32			
C. 0.42			
D. 0.49			
XI. Poisson Process & the Exponential Distribution			
24. A telemedicine platform receives patient consultation requests throughout the day. Historical data indicate that requests arrive randomly and independently at an average rate of 4 requests per hour, modeled as a Poisson process. Let T denote the waiting time (in hours) until the next consultation request arrives. What is the variance of T?			
A. 4			
B. 16			
C. $\frac{1}{4}$			
D. $\frac{1}{16}$			

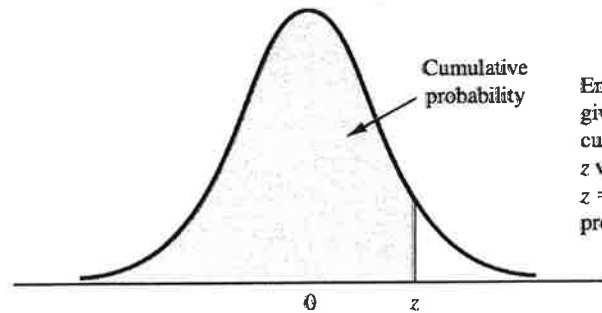
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XII. Design of Experiments

25. In an agricultural experiment, plots of land are grouped according to soil type before assigning fertilizer treatments. The primary purpose of blocking is to:

- A. Increase sample size
- B. Reduce variability due to known factors
- C. Eliminate random error
- D. Increase treatment effects

TABLE 1 Cumulative Probabilities for the standard Normal Distribution
(Continued)



Entries in the table give the area under the curve to the left of the z value. For example, for $z = 1.25$, the cumulative probability is .8944.

z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
.0	.5000	.5040	.5080	.5120	.5160	.5199	.5239	.5279	.5319	.5359
.1	.5398	.5438	.5478	.5517	.5557	.5596	.5636	.5675	.5714	.5753
.2	.5793	.5832	.5871	.5910	.5948	.5987	.6026	.6064	.6103	.6141
.3	.6179	.6217	.6255	.6293	.6331	.6368	.6406	.6443	.6480	.6517
.4	.6554	.6591	.6628	.6664	.6700	.6736	.6772	.6808	.6844	.6879
.5	.6915	.6950	.6985	.7019	.7054	.7088	.7123	.7157	.7190	.7224
.6	.7257	.7291	.7324	.7357	.7389	.7422	.7454	.7486	.7517	.7549
.7	.7580	.7611	.7642	.7673	.7704	.7734	.7764	.7794	.7823	.7852
.8	.7881	.7910	.7939	.7967	.7995	.8023	.8051	.8078	.8106	.8133
.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

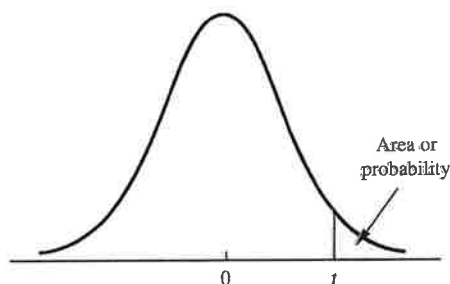
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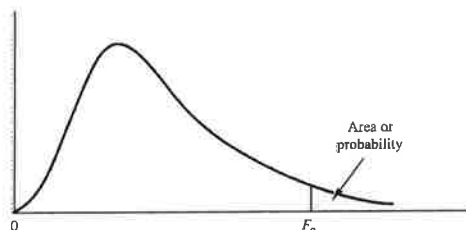
TABLE 2 t Distribution



Entries in the table give t values for an area or probability in the upper tail of the t distribution. For example, with 10 degrees of freedom and a .05 area in the upper tail, $t_{.05} = 1.812$.

Degrees of Freedom	Area in Upper Tail					
	.20	.10	.05	.025	.01	.005
1	1.376	3.078	6.314	12.706	31.821	63.656
2	1.061	1.886	2.920	4.303	6.965	9.925
3	.978	1.638	2.353	3.182	4.541	5.841
4	.941	1.533	2.132	2.776	3.747	4.604
5	.920	1.476	2.015	2.571	3.365	4.032
6	.906	1.440	1.943	2.447	3.143	3.707
7	.896	1.415	1.895	2.365	2.998	3.499
8	.889	1.397	1.860	2.306	2.896	3.355
9	.883	1.383	1.833	2.262	2.821	3.250

TABLE 4 F Distribution



Entries in the table give F_{α} values, where α is the area or probability in the upper tail of the F distribution. For example, with 4 numerator degrees of freedom, 8 denominator degrees of freedom, and a .05 area in the upper tail, $F_{.05} = 3.84$.

Denominator Degrees of Freedom	Area in Upper Tail	Numerator Degrees of Freedom																	
		1	2	3	4	5	6	7	8	9	10	15	20	25	30	40	60	100	1000
1	.10	39.86	49.50	53.59	55.83	57.24	58.20	58.91	59.44	59.86	60.19	61.22	61.74	62.05	62.26	62.53	62.79	63.01	63.30
	.05	161.45	199.50	215.71	224.58	230.16	233.99	236.77	238.88	240.54	241.88	245.95	248.02	249.26	250.10	251.14	252.20	253.04	254.19
	.025	647.79	799.48	864.15	899.60	921.83	937.11	948.20	956.64	963.28	968.63	984.87	993.08	998.09	1001.40	1005.60	1009.79	1013.16	1017.76
	.01	4052.18	4999.34	5403.53	5624.26	5763.96	5858.95	5928.33	5980.95	6022.40	6055.93	6156.97	6208.66	6239.86	6260.35	6286.43	6312.97	6333.92	6362.80
2	.10	8.53	9.00	9.16	9.24	9.29	9.33	9.35	9.37	9.38	9.39	9.42	9.44	9.45	9.46	9.47	9.47	9.48	9.49
	.05	18.51	19.00	19.16	19.25	19.30	19.33	19.35	19.37	19.38	19.40	19.43	19.45	19.46	19.46	19.47	19.48	19.49	19.49
	.025	38.51	39.00	39.17	39.25	39.30	39.33	39.36	39.37	39.39	39.40	39.43	39.45	39.46	39.46	39.47	39.48	39.49	39.50
	.01	98.50	99.00	99.16	99.25	99.30	99.33	99.36	99.38	99.39	99.40	99.43	99.45	99.46	99.47	99.48	99.49	99.49	99.50
3	.10	5.54	5.46	5.39	5.34	5.31	5.28	5.27	5.25	5.24	5.23	5.20	5.18	5.17	5.17	5.16	5.15	5.14	5.13
	.05	10.13	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79	8.70	8.66	8.63	8.62	8.59	8.57	8.55	8.53
	.025	17.44	16.04	15.44	15.10	14.88	14.73	14.62	14.54	14.47	14.42	14.25	14.17	14.12	14.08	14.04	13.99	13.96	13.91
	.01	34.12	30.82	29.46	28.71	28.24	27.91	27.67	27.49	27.34	27.23	26.87	26.69	26.58	26.50	26.41	26.32	26.24	26.14
4	.10	4.54	4.32	4.19	4.11	4.05	4.01	3.98	3.95	3.94	3.92	3.87	3.84	3.83	3.82	3.80	3.79	3.78	3.76
	.05	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96	5.86	5.80	5.77	5.75	5.72	5.69	5.66	5.63
	.025	12.22	10.65	9.98	9.60	9.36	9.20	9.07	8.98	8.90	8.84	8.66	8.56	8.50	8.46	8.41	8.36	8.32	8.26
	.01	21.20	18.00	16.69	15.98	15.52	15.21	14.98	14.80	14.66	14.55	14.20	14.02	13.91	13.84	13.75	13.65	13.58	13.47
5	.10	4.06	3.78	3.62	3.52	3.45	3.40	3.37	3.34	3.32	3.30	3.24	3.21	3.19	3.17	3.16	3.14	3.13	3.11
	.05	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74	4.62	4.56	4.52	4.50	4.46	4.43	4.41	4.37
	.025	10.01	8.43	7.76	7.39	7.15	6.98	6.85	6.76	6.68	6.62	6.43	6.33	6.27	6.23	6.18	6.12	6.08	6.02
	.01	16.26	13.27	12.06	11.39	10.97	10.67	10.46	10.29	10.16	10.05	9.72	9.55	9.45	9.38	9.29	9.20	9.13	9.03