

28. The following are annual profits (in thousands of rupees) in a business form:

Year	1999	2000	2001	2002	2003	2004	2005
Profits (in '000 Rs.):	60	72	75	65	80	85	95

- (a) Use the method of least squares to fit a straight line to the above data.
 (b) Plot the above figures and draw the line.
 (c) Also make an estimate of the profits for the year 2006.
 [Y = 76 + 4.86X; Y₂₀₀₆ = 100.3]

29. Fit a straight line trend by the method of least squares to the following data:

Year (X)	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04
Sales (in lakhs Rs.) (Y):	278	309	335	378	424	481	521

(Clearly specify the origin and the units of the variables in the trend equation obtained.)
 [Y = 389.43 + 41.5X]

30. Fit an equation of the type $Y = a + bX + cX^2$ to the following data:

Year	Production (in '000 tonnes)	Year	Production (in '000 tonnes)
2001	70	2004	80
2002	72	2005	90
2003	88		

31. The following table shows the number of letters posted in a particular area during a typical period of four weeks. Assuming that the trend value during the period remains the same, calculate 'seasonal indices' (here daily indices) as percentage of the grand average:

Week	Sun.	Mon.	Tue.	Wed.	Thurs.	Fri.	Sat.	Total
1	18	161	170	164	153	181	76	923
2	18	165	169	147	148	190	80	917
3	21	162	169	153	155	190	82	932
4	20	165	170	155	150	180	85	925
Total	77	653	678	619	606	741	323	3697

32. The working capital requirements of the XYZ Ltd. have been subject to seasonal fluctuations. At the same time, a steady secular advance can be noted. In order to evaluate comprehensively future working capital needs, the treasurer calculated a straight line trend and the seasonal indices. The trend equation is $Y_c = 10,000 + 500X$, where X represents a period of 1 month and has a value of 0 in 2005. The seasonal indices are as follows:

Jan.	80	July	125
Feb.	95	Aug.	99
Mar.	90	Sep.	90
Apr.	100	Oct.	102
May.	116	Nov.	105
June	120	Dec.	87

- (a) Prepare a schedule of estimated working capital requirements for 2006.
 (b) What factors could cause these estimates to be incorrect?
 (c) What might be done to compensate for inaccuracies as they become apparent?
 (d) Would you as a banker have any interest in estimates of this type?
33. In order to find quarterly seasonal indices, first of all the quarter wholesale price for five years (2001-2005) were reduced as percentage of their centred moving averages of four quarters. These percentages are set out in the following table. You are required to calculate the quarterly seasonal indices.

Year	I	II	III	IV
2001	—	—	127	134
2002	130	122	122	132
2003	120	120	118	128
2004	126	116	121	130
2005	127	118	—	—

I	II	III	IV
101.0	95.6	98.04	105

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34. Consult a copy of Business Statistics in your library and select a series of your own. The series should be for a period of minimum eight years. Then do the following :

- Compute an appropriate trend line for the series, with first month of series as the origin. Plot the original series and trend in one diagram.
 - Compute a typical seasonal index for the series by the ratio-to-moving average method. Plot the actual data and moving average figures.
 - What comments can you make on T , S , C and I ?
35. a) What do you understand by seasonal fluctuation in time series? Give an example.
 (b) What are the major uses of seasonal indices in time series analysis? Name four methods by which one can compute seasonal index from time series data.
 (c) The sales of a company rose from Rs. 60,000 in the month of August to Rs. 69,000 in the month of September. The seasonal indices for these two months are 105 and 140 respectively. The owner of the company was not at all satisfied with the rise of sale in the month of September by Rs. 9,000. He expected much more because of the seasonal index for the month. What were his estimates of sales for the month of September?

$$\left[\text{The expectation was } \frac{60,000 \times 140}{105} = \text{Rs. } 80,000 \right]$$

36. (a) Given the following trend information :

$$Y_c = 60 + 2.48X \quad \text{Origin : July 1, 1996}$$

Y in million of rupees X in terms of years

Convert this equation in monthly terms. Be sure your response is in the most practical form.

(b) The annual trend equation for the XYZ Co. Ltd. is represented by the following :

$$Y_c = 468 + 0.20X \quad X = \text{years}$$

Y = thousands of rupees Origin : July, 1996

- Based on the past several years, monthly sales during January have been around Rs. 50,000. What is the typical seasonal relative for January?
- If your seasonal relative for January was greater than 100, does it necessarily indicate that at least one of the 11 months has a seasonal relative that is less than 100? Explain.

37. Fit a straight line trend to the following data and show the original observations and trend values on the graph paper :

Year	1999	2000	2001	2002	2003	2004	2005
Gross ex-factory value of output	672	824	967	1204	1464	1758	2057

$$[Y = 1278 + 23.86X]$$

38. The number of units of a product exported during 1998-2005 is given below. Fit a straight line trend to the data. Plot the given data showing also the trend.

Year	1998	1999	2000	2001	2002	2003	2004	2005
No. of units (in thousands)	12	13	13	16	19	23	21	23

$$[Y = 17.5 + 0.893X]$$

39. Calculate seasonal indices by the 'ratio-to-moving average method' from the following data :

Year	I Quarter	II Quarter	III Quarter	IV Quarter
2002	68	62	61	63
2003	65	58	66	61
2004	68	63	63	67

$$[105.3; 95.21; 100.97; 98.52]$$

40. The sales of a company rose from Rs. 40,000 in March to Rs. 48,000 in April 2003. The company's seasonal indices for these two months are 105 and 140 respectively. The owner of the company expressed dissatisfaction with the April sales but the Sales Manager said that he was quite pleased with the Rs. 8,000 increase. What argument should the owner of the company have used to reply the Sales Manager?

The Sales Manager also predicted on the basis of the April sales that the total 2002 sales were going to be Rs. 5,76,000. Criticise the Sales Manager's estimate and explain how the estimate of Rs. 4,11,000 may be arrived at.

41. The following table shows the number of salesmen working in a certain concern :

Year	2000	2001	2002	2003	2004
No. of salesmen	28	38	46	40	56

Use the method of least squares to fit a straight line trend and estimate the number of salesmen in 2006.

2. The materials manager of a company has projected 10, 15 and 18 truckloads of a product for three consecutive months. The seasonal indices for these are 141.5, 125.8 and 82.6 respectively. Work out the seasonalised forecast for each month of three months.
3. The seasonal indices of the sale of readymade garments of a particular type in a departmental store are given below

	Quarter	Seasonal index
I	Jan.—March	95
II	April—June	80
III	July—Sept.	90
IV	Oct.—Dec.	125

If the total sales in the first quarter of the year be worth Rs. 50,000, determine how much worth of garments of this type should be kept in store to meet the demand in each of the remaining quarters.

[50,000; 42,145.26; 47,368.42; 65,789.47]

44. A company estimates its sales for a particular year to be Rs. 24,00,000. The seasonal indices for sales are as follows :

Months	Seasonal index	Months	Seasonal index
January	75	July	102
February	80	August	104
March	98	September	100
April	128	October	102
May	137	November	82
June	119	December	73

Using the information, calculate the quarterly sales of the company. Assume that there is no trend. (MBA, Osmania Univ., 2002)

45. The following figures are the production data of a sugar factory :

Year	Production ('000 tonnes)	Year	Production ('000 tonnes)
1995	17	2001	35
1996	20	2002	35
1997	19	2003	51
1998	26	2004	74
1999	24	2005	79
2000	40		

Fit the trend of the type $Y = a + bX + cX^2$ to the above data. Select the year 2000 as the working origin.

46. Using the data given below, explain how would you determine seasonal fluctuations in a time series :

Year	Summer	Monsoon	Autumn	Winter
2000	30	81	62	199
2001	33	104	86	171
2002	42	153	99	221
2003	56	172	129	235
2004	67	201	136	302

47. The number of units produced during 1998-2005 are given below :

Year	1998	1999	2000	2001	2002	2003	2004	2005
Units produced	56	55	51	47	42	38	35	32

- (i) Fit a straight line trend and obtain the trend values.
 (ii) Eliminate the trend. What components of the time series are thus left over?
 (iii) What is the monthly increase in the number of units produced?

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Mon. 12

2001-2008

12

Handwritten notes:
 Non Linear
 2000-2008
 2008
 2004

48. Compute a nonlinear trend of the form $Y = a + bX + cX^2$ for the data showing the production of wheat (in thousand tonnes) during the years 1997 to 2005.

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005
Production of wheat ('000 tonnes)	9	10	12	15	13	10	8	16	15

(Take the year 2001 as working origin)

49. Find the trend values by the method of least squares for the following time series :

Year	1997	1998	1999	2000	2001	2002	2003	2004	2008
Production ('000 tonnes)	351	366	362	400	419	420	450	518	

Estimate the likely production for the year 2008.

50. Use method of least squares to determine sales for the year 2004.

Year	1997	1999	2000	2001	2002
Sales	100	110	130	125	160

(MBA, Anna Univ., 2002)

51. Fit a straight line trend by the method of least squares to the following data :

Year	1996	1997	1998	1999	2000	2001	2002	2003
Earnings (Rs. Lakhs)	38	40	65	72	69	60	87	95

(M.Com. Madurai Kamaraj, 2002)

52. The projected number of women of child bearing age (15-49) for the years from 1996 to 2003 are as follows :

Year	1996	1997	1998	1999	2000	2001	2002	2003
No. of Women (in millions)	152.6	154.1	160.3	164.4	168.5	172.7	176.9	181.2

Fit a trend line.

(MBA, Anna Univ., 2002)

53. What is meant by moving average? Find the trend for the following series by three year weighted average with weights 1, 2, 1 :

Year (coded value)	-3	-2	-1	0	1	2	3
Sales (in thousand units)	2	4	5	7	8	10	13

(MBA, M.D. Univ., 2000)

54. The following are the annual profits in thousands of rupees, in a certain business :

Year	Profits (Rs. '000)	Year	Profits (Rs. '000)
1996	60	2000	80
1997	72	2001	85
1998	75	2002	95
1999	65		

(i) Use the method of least square to fit a straight line trend to the above data.

(ii) Also make an estimate of the profits for the year 2004.

(M.Com., M.K. Univ., Nov. 2002)

55. The following table gives the total expenditure of the Government during 1996-2003. Fit a quadratic trend to the data :

Year	1996-97	97-98	98-99	99-00	00-01	01-02	02-03
Expenditure	177.2	185.0	224.9	254.0	304.9	359.9	438.8

(MBA, Anna Univ., 2001)

Illustration 34. Given the probabilities of three events, A , B and C are $P(A) = 0.35$, $P(B) = 0.45$ and $P(C) = 0.2$. Also that A , B and C have occurred, the conditional probabilities of another event, X , occurring are $P(X/A) = 0.8$, $P(X/B) = 0.65$ and $P(X/C) = 0.3$. Find $P(A/X)$, $P(B/X)$ and $P(C/X)$.

Solution. We shall make use of Bayes' theorem to solve this problem.

Given $P(A) = 0.35$
 $P(B) = 0.45$
 $P(C) = 0.20$

Also

$P(X/A) = 0.80$
 $P(X/B) = 0.65$
 $P(X/C) = 0.30$

$$P(A/X) = \frac{P(A) P(X/A)}{P(A) P(X/A) + P(B) P(X/B) + P(C) P(X/C)}$$

$$= \frac{0.35 \times 0.8}{(0.35 \times 0.8) + (0.45 \times 0.65) + (0.2 \times 0.3)}$$

$$= \frac{0.28}{0.28 + 0.29 + 0.06} = \frac{0.28}{0.63} = 0.44$$

$$P(B/X) = \frac{P(B) P(X/B)}{P(A) P(X/A) + P(B) P(X/B) + P(C) P(X/C)}$$

$$= \frac{(0.45)(0.65)}{(0.35 \times 0.8) + (0.45)(0.65) + (0.2)(0.3)}$$

$$= \frac{0.29}{0.28 + 0.29 + 0.06} = \frac{0.29}{0.63} = 0.46$$

$$P(C/X) = \frac{P(C) P(X/C)}{P(A) P(X/A) + P(B) P(X/B) + P(C) P(X/C)}$$

$$= \frac{(0.2)(0.3)}{(0.35 \times 0.8) + (0.45 \times 0.65) + (0.2 \times 0.3)}$$

$$= \frac{0.06}{0.28 + 0.29 + 0.06} = \frac{0.06}{0.63} = 0.09$$

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PROBLEMS

1-A : Answer the following questions, each question carries **one** marks:

- State the addition law of probability. (MBA, Madurai-Kamaraj, 2001)
- What do you mean by the term conditional probability? (MBA, Madurai-Kamaraj, April, 2002)
- A bag contains 7 red balls and 5 white balls. 2 balls are drawn at random. What is the probability that all of them are red?
- Define the term probability. (M.Com., Madurai Kamaraj, 2002; M.A. Econ. M.K. Univ., 2002)
- What are independent events? (MBA, Madurai-Kamaraj, Nov. 2002)
- Explain with examples the rule of addition in theory of probability. (MBA, Madurai-Kamaraj, Nov. 2002)
- What is meant by mutually exclusive events? (M. Com., M.K. Univ., Nov. 2002)
- What is Bayes' theorem? (MBA, Bharathidasan Univ., Nov. 2002)

1-B : Answer the following questions, each question carries **four** marks:

- Three balls are drawn at random from a basket containing 6 blue and 4 red balls. What is the chance that two balls are blue and one is red?
 - What is the probability that a leap year selected at random will contain 53 Sundays? (M. Com., M.K. Univ., April 2002)
 - What do you mean by probability? Explain the importance of probability. (M.A. Econ., Madras Univ., 2002)
 - What are the basic laws of probability? (MBA, Madras Univ., Nov. 2002)
 - State and prove the addition law of probability.
2. Explain what do you understand by the term probability. Discuss its importance in business decision-making. (MBA, DU, 2002)
3. Describe briefly the various schools of thought on probability. How does the concept of probability help decision-makers to improve his decisions? (MBA, HPU, 1998; MBA, DU, 1998)

- (a) Explain the various approaches to probability. Are they contradictory?
 (b) Examine critically the different schools of thought on probability. (MBA, Rohilkhand Univ., 1999)
5. Explain with examples the rules of Addition and Multiplication in theory of probability. (MBA, DU, 1999; MBA, Kumaon Univ., 2000)
6. Give the classical and statistical definitions of probability and state the relationship, if any, between the two definitions. (MBA, HPU, 1997)
7. State and prove the addition and multiplication theorems of probability.
8. (a) Explain with the help of an example the concept of conditional probability. (MBA, Delhi Univ., 1999)
 (b) Explain the concept of conditional probability and Bayes' theorem. (MBA, IGNOU, Dec. 2002)
9. Explain the difference between :
 (i) Simple probability and conditional probability.
 (ii) Independent event and mutually exclusive event.
10. Define independent and mutually exclusive events. Can two events be mutually exclusive and independent simultaneously? Support your answer with an example. (MBA, Sukhadia Univ.; MBA, Delhi Univ., 1999)
11. When are two events said to be independent in the probability sense? Give examples of dependent and independent events. (MBA, Delhi Univ., 1998)
12. (a) Explain the concept of probability following the experimental frequency approach.
 (b) What do you understand by conditional probability? If $\text{Prob.}(A + B) = \text{Prob.}(A) + \text{Prob.}(B)$, are the two events A and B statistically independent?
13. Write an essay on prior and posterior probabilities and Bayes' theorem and also show how Bayes' theorem can be extended in the case of n events.
14. (a) Make up a realistic problem from your area of interest to illustrate the use of Bayes' theorem.
 (b) State the multiplicative theorem of probability. How is the result modified if the events are independent? (M.Com., DU, 1999)
15. The personnel manager of a large manufacturing firm finds that 10 per cent of the firm's employees are junior executives and 25 per cent of the firm's employees are MBAs. He also discovers that 5 per cent of the firm's employees are both junior executives and MBAs. What is the probability of selecting a junior executive if the selection is confined to MBAs? [0.20]
16. A company learned that inventory shortages were associated with a loss of goodwill with a probability 0.10. The company also knew that a loss of goodwill from all causes occurred with a probability of 0.15. What is the probability of an inventory shortage, given a loss of goodwill? [0.67]
17. An article manufactured by a company consists of two parts A and B . In the process of manufacture of part A , 9 out of 100 are likely to be defective. Similarly, 5 out of 100 are likely to be defective in the manufacture of part B . Calculate the probability that the assembled part will not be defective. [0.8645]
18. A candidate is selected for interview for three posts. For the first post there are 3 candidates, for the second there are four and for the third there are two candidates. What are his chances of getting at least one post? [0.75]
19. An investment firm purchases 3 stocks for one week trading purposes. It assesses the probability that the stocks will increase in value over the week as 0.8, 0.7 and 0.6 respectively. What is the chance (i) all three stocks will increase and (ii) at least 2 stocks will increase? (Assume that the movements of these stocks are independent.) [(i) 0.336, (ii) 0.788.]
20. A company has two plants to manufacture scooters. Plant 1 manufactures 80% of the scooters and plant 2 manufactures 20%. At Plant 1, 85% scooters are rated as standard quality. At plant 2, only 65% scooters are rated as standard quality. (MBA, Delhi Univ., 1998)
 (i) What is the probability, that a customer obtains a standard quality scooter if he buys a scooter from the company?
 (ii) What is the probability, that the scooter came from plant 1, if it is known that the scooter is of standard quality?
21. 10% of the employees of a certain company have been to public school. Of these, 30% hold administrative positions. Of these that have not been to public school, 30% hold administrative positions. If an employee is selected at random from the administrative staff, what is the probability that he was educated in a public school? [(i) 0.81, (ii) 0.84]
22. A factory produces a mechanism which consists of three independently manufactured parts. It is known that 1 per cent of part one, 4 per cent of part two and 3 per cent of part three are defective. What is the probability that a complete mechanism is not defective? [0.9218]

410 Business Statistics

23. A manager has two assistants and he bases his decision on information supplied independently by each of them. The probability that he makes a mistake in his thinking is 0.005. The probability that an assistant gives wrong information is 0.01. Assuming that the mistakes made by the manager are independent of the information given by the assistants, find the probability that he reaches a wrong decision.
(MBA, DU, 2001)
[0.5122]
24. A piece of electronic equipment has two essential parts, A and B. In the past, part A has failed 40% of the time; part B 30% of the time. Parts A and B operate independently. Assume that both parts must operate to enable the equipment to function. What is the probability that the equipment will function?
[0.30]
25. Three groups of workers contain 3 men and 1 woman, 2 men and 2 women, and 1 man and 3 women, respectively. A worker is selected at random from each group. What is the probability that the group selected consists of 1 man and 2 women?
[0.4063]
26. Two sets of candidates are competing for the position on the Board of Directors of a company. The probability is that the first and second sets will win 0.6 and 0.4 respectively. If the first set wins, the probability of introducing a new product is 0.8, and the corresponding probability if the second set wins is 0.3. What is the probability that the new product will be introduced?
[0.60]
27. There are three cars, A, B and C. Car A, contains two males, car B contains one male and one female, and car C contains two females. If one of these cars is selected at random, and one person is observed to be male, what is the probability that the other person in that car is male?
[2/3]
28. A salesman has a 60 per cent chance of making a sale to each customer. The probability of successive customers is independent. If two customers A and B enter, what is the probability that the salesman will make a sale to A or B?
(MBA, DU, 1998)
[0.84]
29. A factory produces certain types of output by three machines. The respective daily production figures are: Machine A = 3,000 units; Machine B = 2,500 units; and Machine C = 4,500 units. Past experience shows that 1 per cent of the output produced by machine A is defective, and the corresponding fractions of defectives for the other two machines are 1.5 and 2 per cent respectively. An item is drawn at random from the day's production run and is found to be defective. What is the probability that it comes from the output of (i) Machine A; (ii) Machine B; and (iii) Machine C?
[(i) 0.2; (ii) 0.2; (iii) 0.6]
30. In a bolt factory machines A, B and C manufacture respectively 25%, 35% and 40%. Of the total of their output 5, 4 and 2 per cent are defective bolts. A bolt is drawn at random from the product and is found to be defective. What are the probabilities that it was manufactured by machines A, B and C?
(M.Com., MD, 2001)
[A = 0.37; B = 0.40; C = 0.23]
31. In a factory manufacturing pens. Machines X, Y and Z manufacture 30, 30 and 40 per cent of the total production of pens respectively. Of their output 4, 5 and 10 per cent of the pens are defective. If one pen is selected at random it is found to be defective, what is the probability that it is manufactured by machine Z?
[0.6639]
32. The probability that India wins a cricket test match against Pakistan is, given to be 1/3. If India and Pakistan play six test matches, what is the probability that:
(i) India will lose all the six test matches?
(ii) India will win at least one test match?
[(i) 0.088; (ii) 0.912]
33. Three persons A, B and C are being considered for the appointment as Vice-Chancellor of a university whose chances of being selected for the post are in the proportion 4:2:3 respectively. The probability that A, if selected, will introduce democratisation in the University Structure is 0.3 and the corresponding probabilities for B and C doing the same are respectively 0.5 and 0.8. What is the probability that democratisation would be introduced in the University?
(MBA, DU, 2001)
[0.511]

17. A husband and wife appear in an interview for two vacancies in the same post. The probability of husband's selection is $\frac{1}{7}$ and that of wife's selection is $\frac{1}{5}$. What is the probability that
- both of them will be selected,
 - only one of them will be selected, and
 - none of them will be selected?
- [10] (a) $\frac{1}{35}$, (b) $\frac{10}{35}$, (c) $\frac{24}{35}$ (MBA, DU, 1999; M. Com., Madurai Kamaraj, Nov. 2003)
18. A hotel gets cars for its guests from three rental agencies, 20 per cent from agency X, 40 per cent from agency Y and 40 per cent from Z. If 14 per cent of the cars from X, 12 per cent from Y and 8 per cent from Z, need tune-ups, what is the probability that car needing a tune-up is delivered to one of the hotel's guests? (MBA, DU, 1999)
- [10]
19. The odds against student X solving a Business statistics problem are 11 : 6 and odds in favour of student Y solving the same problem are 14 : 16. (i) What is the chance that the problem will be solved if both try? (ii) What is the probability that they both, working independently of each other, solve the problem? (iii) What is the probability that neither solves the problem? [10] (i) 0.6952; (ii) 0.2; (iii) 0.3048 (MBA, DU, 2003; MBA, M.K. Univ., Nov. 2003)
20. In a certain government office there are 400 employees; there are 150 men, 276 University graduates, 212 married persons, 94 male university graduates, 151 married university graduates, 119 married men, 72 married male university graduates. Find the number of single women who are not university graduates? [5]
21. A lot of vacuum tubes contains 1000 tubes. 10 of which have a defective grid and no other defects and 20 of which have both a defective grid and defective heating element. A tube is drawn at random from the lot and we are told that it has defective grid. What is the probability that it also has a defective heating element? What model did you use in computing this probability?
22. Probability that a man will be alive 25 years hence is 0.3 and the probability that his wife will be alive 25 years hence is 0.4. Find the probability that 25 years hence (i) both will be alive (ii) only the man will be alive (iii) only the woman be alive and (iv) at least one of them will be alive. (MBA, Vikram Univ., 1994)
23. A convention begins with an evening lecture, attended by 60% of the delegates. The following morning lecture is attended by 10% of the delegates. Seventy per cent of those attending this session had attended the previous evening session.
- What is the probability that a randomly selected delegate attended both the sessions?
 - What is the probability that a delegate who attended the evening session also attended the following morning session?
 - What is the probability that a delegate selected at random attended at least one of the two sessions?
 - Are attendances at the two sessions statistically independent?
24. Mr. Ram speaks the truth in 3 out of 4 times, while Mr. Shyam speaks the truth in 4 out of 5 times. Find the probability that they will contradict each other in stating the fact. (MBA, Delhi Univ., 1998)
- [10]
25. Two union leaders and 10 directors of a company sit randomly around a round table to decide upon the wage hike as demanded by the union. Find the probability that there will be exactly three directors between the two union leaders.
26. Assume we have three boxes which contain red and black balls as follows:
- | | | |
|-------|---|-------------------|
| Box 1 | — | 3 red and 7 black |
| Box 2 | — | 6 red and 4 black |
| Box 3 | — | 8 red and 2 black |
- A ball is drawn from box 1; if it is red, 2nd ball is drawn from box 2. If the 1st ball drawn from box 1 is black, 2nd ball is drawn from box 3.
- What is the probability that the two balls are red?
 - What is the probability that one ball is red and another ball is black?
27. Explain whether or not each of the following claims could be correct:
- A supplier claims that the long-run fraction of the resistors he produces which are defective is 0.001. In one lot of 10,000 resistors obtained from the supplier 30 defectives were discovered.
 - A plant engineer claims the probability that machine will not fail in a one month period is 0.20, the probability that it will fail exactly once is 0.50, the probability that it will fail twice is 0.30 and the probability that it will fail more than twice is 0.30.
 - A market analyst claims that the probability that sales of less than 4 million pounds in the next year is 0.3, of sales between 4 and 6 million pounds is 0.4 and sales of more than 6 million pounds is 0.2.

412 Business Statistics

45. A production process which turns out transistors has a long-run fraction defective of 0.005. A testing device is used to check each transistor produced. It has been found that the device always indicates that a defective is indeed defective, but for every 1 in every 100 transistors produced it indicates that a good transistor is defective. If the device indicates that a transistor is defective, what is the probability that it is actually defective?
46. A certain production process produces items that are 10 per cent defective. Each item is inspected before being supplied to customers but the inspector incorrectly classifies an item 10 per cent of the time. Only items classified as good are supplied. If 820 items in all have been supplied, how many of them are expected to be defective?

[10]

47. A market research firm is interested in surveying certain attitudes in a small community. There are 1,250 households broken down according to income, ownership of a telephone and ownership of a TV.

	Households with annual income of Rs. 3,00,000 or less		Household with annual income above Rs. 3,00,000	
	Telephone Subscriber	No Telephone	Telephone Subscriber	No Telephone
	Own TV set	270	200	180
No TV set	180	100	120	100

- (i) What is the probability of obtaining a TV owner in drawing at random?
- (ii) If a household has annual income over Rs. 3,00,000 and is a telephone subscriber, what is the probability that he has a TV?
- (iii) What is the conditional probability of drawing a household that owns a TV given that the household is a telephone subscriber.
- (iv) Are the events 'ownership of a TV' and 'telephone subscriber' statistically independent? Comment.
- [(i) 0.6, (ii) 0.6, (iii) 0.6, (iv) yes]

48. Past surveys show that 40% of the officers at a certain industry own cars. Suppose six officers are selected at random from this industry (with replacement).
- (a) What is the probability that exactly four will own cars?
- (b) What is the probability that at least one will own a car?
- (c) What is the theoretical mean of the probability distribution under consideration? (MBA, Osmania Univ., 1998)

49. A survey reports that 80% of the population is married and 55% is male. What is the least possible percentage of married men and of married women?

50. Consider a family with two children. Assuming that each child is as likely to be a boy as it is to be a girl, what is the conditional probability that both children are boys given that (a) the elder child is a boy, (a) at least one of the children is a boy?

51. A man goes for fishing for the first time. He has three types of bait, only one of which is correct for the type of fish he intends to try. The probability that he will catch a fish if he uses correct bait is $1/3$. If he uses the wrong bait, his chances of catching a fish are $1/5$.

- (a) What is the probability that he will catch a fish?
- (b) Given the man caught a fish, what is the probability that he used correct type of bait?

52. If a machine is correctly set up, it will produce 90% acceptable items. If it is incorrectly set up, it will produce 10% acceptable items. Past experience shows that 80% of the set-ups are correctly done. If after a certain set-up the machine produces 2 acceptable items as the first 2 pieces, find the probability that the machine is correctly set up.

53. Consider two events A and B such that $P(A) = 1/8$, $P(A/B) = 1/4$ and $P(B/A) = 1/6$. Examine the following statements and comment on the validity of each of these:

- (i) A and B are independent.
- (ii) A and B are mutually exclusive.
- (iii) Occurrence of A implies that of B .
- (iv) $P(A/B) = 0.5$.

54. If a pair of dice is thrown, find the probability that the sum is neither 7 nor 11.
- [7/9]

55. An investment consultant predicts that the odds against the price of a certain stock will go up during the next week are 1 and the odds in favour of the price remaining the same are 1 : 3. What is the probability that the price of the stock will go down during the next week?

56. (a) What is the probability that a leap year selected at random will contain either 53 Thursdays or 53 Fridays?
- [3/71]

- (b) What is the probability that a leap year selected at random will contain 53 sundays?

(M. Com., Madurai-Kamraj Univ., 1998)

57. A product is assembled from three components X, Y and Z and the probability of these components being defective is 0.01, 0.02 and 0.05. What is the probability that the assembled product will not be defective?
[0.922] (MBA, DU, 2002)
58. According to a survey, the probability that a family owns 2 cars if their annual income is greater than Rs. 15,000 is 7. Of the households surveyed, 50 per cent had income over Rs. 15,000 and 40 per cent had 2 cars. What is the probability that a family has 2 cars and an income over Rs. 15,000 a year?
59. A box contains 8 red, 3 blue and 9 green balls. If three balls are drawn at random, determine the probability that :
(i) all 3 are red ; (ii) all 3 are blue ; (iii) at least 1 is blue ; (iv) 2 are red and 1 green
(v) 1 of each colour ; and (vi) the balls are drawn in the order red, blue and green colours.
60. A problem in statistics is given to the three students X, Y and Z, whose chances of solving it are $1/3$, $1/4$, $2/5$ respectively. What is the probability that the problem will be solved?
[7/10]
61. A survey of readership of a certain investment magazine indicates that the proportion of male readers over 40 years is 0.02. The proportion of male readers under 40 is 0.07. What is the probability of a reader being a male?
62. The cricket team of a University played four matches in Inter-University cricket matches. The captain of the team observed the practice of calling out "Heads" every time when the toss was made. What is the probability of his winning the toss in all the four matches?
How would the probability be affected if the Captain had made a practice of tossing coin privately before calling out "Head" or "Tail" on each occasion?
63. A sample of 3 items is selected at random from a box containing 12 items of which 3 are defective. Find the possible number of defective combinations of 1 and 2 selected items along with probability of a defective combination.
64. In an examination, 30% of the students have failed in Mathematics, 20% of students have failed in Chemistry and 19% have failed in both Mathematics and Chemistry. A student is selected at random.
(i) What is the probability that the student has failed in Mathematics if it is known that he has failed in Chemistry?
(ii) What is the probability that the student has failed in Mathematics or in Chemistry?
65. A company has four production sections, viz., S_1 , S_2 , S_3 and S_4 which contribute 30%, 20%, 22% and 28% respectively to the total output. It was observed that these sections respectively produced 1%, 2%, 3% and 4% defective units. If a unit is selected at random and found to be defective, what is the probability that the unit so selected has come from either section one or section four?
(MBA, GGSIPU, 2000; MBA, DU, Nov. 2004)
66. A factory has two machines. The empirical evidence has established that Machines (i) and (ii) produce 30% and 70% of the output respectively. It has also been established that 5% and 1% of the output produced by these machines respectively was defective. A defective item is drawn at random. What is the probability that the defective item was produced by machine (i) and (ii)?
[(i) 0.682 (ii) 0.318]
67. It is believed that in 100 cases of income tax raids, and undisclosed income of more than Rs. 1 lakh is selected. What is the probability that the income tax office will have to make at most 10 raids until the first case of undisclosed income of more than Rs. 1 lakh is detected.
68. A box contains 10 white, 7 black and 3 green balls. 2 balls are drawn at random. Find out the probability that :
(i) both are white.
(ii) one is white and another is green.
(iii) one is black and another is green.
Find the probabilities in case of without replacement.
69. Project VIJAY, NCSO, INDIA sums its operations on 10 computers which may need repairs from time to time during the day. Three of these computers are old, each having a probability of $1/11$ of needing repair during the day and seven are new, having corresponding probability of $1/21$.
Assuming that no computer needs repair twice on the same day, determine the probabilities that on a particular day.
(i) just 2 old and no new computers need repair.
(ii) if just 2 computers need repair, they are of same type.
(MBA, IGNOU, Dec. 2000)
70. A consignment of 20 picture tubes contain 5 defectives. Two tubes are selected one after another at random. Find the probability that both are defective assuming (a) the first is replaced before drawing the second, and (b) the first is not replaced.
(MBA, Sukhadia Univ. 1998)

414 Business Statistics

71. A manager has drafted a scheme for the benefit of employees. To get an idea of the support for the scheme, he randomly polls literate workers (L) and illiterate workers (I). He polls 30 of each group with the following results :

Opinion For Scheme	L	I
Strongly Support	9	10
Mildly Support	11	3
Undecided	2	2
Mildly oppose	4	8
Strongly oppose	4	7

- (a) What is the probability that a literate worker selected randomly from the polled group mildly supports the scheme ?
- (b) What is the probability that a worker (literate or illiterate) selected randomly from the polled group strongly or mildly supports the scheme ?
(MBA, IGNOU, June 2003)
72. Three institutions (A, B, and C) train students for MBA entrance test. They train in the proportion 25 per cent (A), 35 per cent (B) and 40 per cent (C) of the trained candidates, for A, B, C; 5 per cent, 4 per cent and 2 per cent are successful in the entrance test respectively.
A candidate is selected at random and found to be successful in the entrance, find the probability, that he was trained by A, B, or C. What is the probability of average success in the MBA entrance ? (MBA, Bharathidasan Univ., April 2003)
73. A man either drives a car or catches a train to go to office each day. He never goes 2 days in a row by train but if he drives one day, then the next day he is just as likely to drive again as he is to travel by train. Now suppose that on the first day of the week, the man tossed a fair dice and drove to work if and only if a 6 appeared. Find the probability that he takes a train on the third day and also the probability that he drives to work in the long run. (B.E./B. Tech Madras Univ., 2003)
74. A machine goes out of order, whenever a component fails. The failure of this part follows a Poisson process with a mean rate of 1 per week. Find the probability that 2 weeks have elapsed since last failure. If there are 5 spare parts of this component in an inventory and that the next supply is not due in 10 weeks, find the probability that the machine will not be out of order in the next 10 weeks.
(B.E./B. Tech, Madras Univ., 2003)
75. A manufacturing firm produces pipes in two plants I and II with daily production 1,500 and 2,000 pipes respectively. The fraction of defective pipes produced by the two plants I and II are 0.006 and 0.008 respectively. If a pipe selected at random from the day's production is found to be defective, what is the probability that it has come from plant I, plant II ?
(MBA, Bharathidasan Univ., Nov. 2003)

Jewel's Care Collected

Illustration 43. Assume that the test scores from a college admissions test are normally distributed with a mean of 450 and standard deviation of 100.

- (i) What percentage of the people taking the test score are between 400 and 500 ?
- (ii) Suppose someone received a score of 630. What percentage of the people taking the test score better? What percentage score worse ?
- (iii) If a particular university will not admit anyone scoring below 480, what percentage of the persons taking the test would be acceptable to the university ?

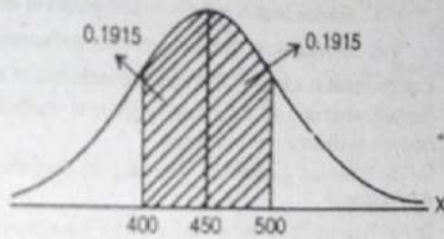
Solution : Let X denote the test scores.

(MBA, DU, Oct., 2003)

$$X \sim N(450, 100)$$

(i)
$$z_1 = \frac{X - \mu}{\sigma} = \frac{500 - 450}{100} = 0.5$$

$$z_2 = \frac{400 - 450}{100} = -0.5$$



Corresponding to $z = 0.5$, the area is 0.1915.

The required probability = $0.1915 \times 2 = 0.3830$

Hence, percentage of the people taking the test score between 400 and 500 is 38.30 per cent.

(ii)
$$z = \frac{630 - 450}{100} = 1.8$$

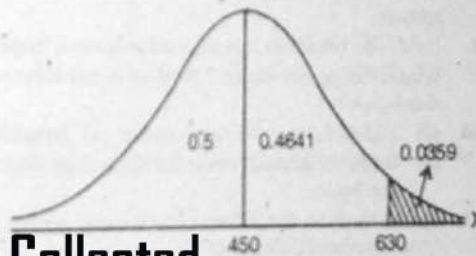
Corresponding to $z = 1.8$, the area is 0.4641.

The required prob = $0.5 - 0.4641 = 0.0359$ for

test score better and required probability

$$= 1 - 0.0359 = 0.9641.$$

Hence, only 3.59 per cent are better and 96.41 per cent are worse.



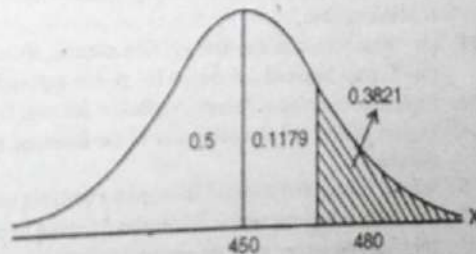
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(iii)
$$z = \frac{480 - 450}{100} = 0.30$$

For $z = 0.30$, the area is 0.1179

$$\text{required Prob.} = 0.5 - 0.1179 = 0.3821$$

Therefore, the per centage of the persons taking the test score acceptable is 38.21.



PROBLEMS

1-A : Answer the following questions, each question carries one mark:

- (i) What is binomial distribution ?
- (ii) What is Bernoulli trial ?
- (iii) What is normal distribution ?
- (iv) Define binomial distribution ?
- (v) Write the parameters of binomial distribution.
- (vi) Write the distribution in which mean and variance will be the same.
- (vii) Mean value of binomial distribution is
- (viii) Define normal distribution.
- (ix) What is normal probability distribution ?
- (x) Mean value of Poisson distribution is
- (xi) What is Poisson distribution ?

(MBA, Madurai-Kamaraj, 2001)

(MBA, Madurai-Kamaraj, April 2001)

(MBA, Madurai-Kamaraj, April 2003; M.A. Eco., M.K. Univ., 2003)

(MBA, Madurai-Kamaraj, Nov. 2003)

(MBA, Madurai-Kamaraj, Nov. 2003)

(M.Com., Madurai-Kamaraj, 2002)

(MBA, Madurai-Kamaraj, Nov. 2003)

(M.Com., M.K. Univ., Nov. 2002)

- (xii) Explain any two properties of normal distribution. (M.A. Eco., M.K. Univ., 1995)
- 1-B : Answer the following questions, each question carries four marks:
- (i) Distinguish between
 - (i) The mean of a binomial distribution is 20 and standard deviation is 4. Find out n , p , and q . (M. Com., M.K. Univ., 1995)
 - (ii) Define Poisson distribution and state its uses. (M. Com., M.K. Univ., 1995)
 - (iii) Define Binomial distribution. The parameters of a binomial distribution are $n = 10$ and $p = 0.2$. Find the mean and variance of the distribution. (MBA, Madras Univ., 1995)
 - (iv) Give at least five important properties of normal distribution.
 - (v) In what ways, Binomial, Poisson and normal distribution are related.
2. Explain, what is meant by Probability distribution of a discrete random variable.
 3. Explain, what do you understand by the term 'mathematical expectation'. How is it useful for a businessman? Give an example to illustrate its usefulness. (MBA, Delhi Univ., 1995)
 4. Define Binomial distribution. Point out its chief characteristics and uses. Under what conditions, it tends to be a normal distribution? (MBA, Osmania Univ., 1995)
 5. Define Normal distribution? What are the main characteristics of Normal Distribution?
 6. What is Binomial distribution? Under what conditions will it tend to Normal distribution?
 7. What are the chief properties of Normal distribution? Describe briefly the importance of Normal distribution in business analysis. (MBA, Delhi Univ., 1995)
 8. Under what conditions, can observed (empirical) frequency distributions be approximated to binomial distribution?
 9. What is Poisson distribution? Point out its role in business decision-making. Under what conditions will it tend to be a normal distribution? (MBA, Karnataka Univ., 1995)
 10. (a) Explain the term 'Random variable' and 'Probability distribution of a random variable'.
(b) Define the Binomial variate and obtain its probability distribution function. Find the mean and variance of the binomial distribution.
 11. Discuss the distinctive features of the binomial, poisson and normal distribution. When does a binomial distribution become a normal distribution? (MBA, Sukhadia Univ., 1995; MBA, Karnataka Univ., 1995)
 12. Under what conditions is the binomial probability distribution model appropriate? How does it approach the Poisson probability distribution as a limiting case?
 13. (a) What is Poisson distribution? Give example where it can be applied.
(b) Explain binomial distribution and give its application in business management.
 14. Explain the meaning of Poisson distribution and state the conditions under which this distribution is used.
 15. Explain briefly, the characteristics of the Binomial and Poisson distributions. How are their means and variances calculated?
 16. What is Poisson distribution? Distinguish clearly the relationship between the Binomial and Poisson distribution.
 17. (a) What is hypergeometric distribution? Explain its properties.
(b) State the properties of the normal distribution.
(c) Describe briefly, the importance of normal distribution in business decision-making. What are its chief properties in statistics?
 18. (a) Briefly describe the characteristics of the normal probability distribution. Why does it occupy such a prominent position in statistics?
(b) When can Poisson distribution be a reasonable approximation of the binomial? (M. Com., DU, 1990)
(c) Fifty per cent of all automobile accidents lead to property damage of Rs. 100. Forty per cent lead to damage of Rs. 200. Ten per cent lead to total loss, a damage of Rs. 1,800. If a car has a 5 per cent chance of being in an accident, what is the expected value of the property damage due to that possible accident?
 19. Suppose that in a lottery 1,000 tickets are sold at Rs. 10 each, and three prizes are to be awarded. The first prize is a television set worth Rs. 12,000, second prize is a short wave radio worth Rs. 1,500; and the third prize is a cycle worth Rs. 1,300. If you plan to buy one ticket, what is your expected gain or loss from the venture?
 20. Two investment opportunities are open to prospective investor. If opportunity A turns out to be successful, a profit of Rs. 10 lakhs will result and the probability of A 's success is estimated as 0.75, if A turns out to be a failure there will be a loss of Rs. 1 lakh. If opportunity B succeeds a profit of Rs. 25 lakhs will materialize but, if it fails, there will be a loss of Rs. 10 lakhs. The probability for B to fail is 0.55. Which investment opportunity should the investor take if the decision is to maximize profit?
[Opportunity B]
 21. If it rains, a raincoat dealer can earn Rs. 5000 per day. If it is fair, he can lose Rs. 1000 per day. What is his expected profit if the probability of rain is 0.4?
[Rs. 1400]

21. A firm plans to bid Rs. 3000 per tonne for a contract to supply 1,000 tonnes of a metal. It has two competitors A and B and it assumes that the probability that A will bid less than Rs. 3000 per tonne is 0.3 and that B will bid less than Rs. 3000 per tonne is 0.7. If the lowest bidder gets all the business and the firms bid independently, what is the expected value of the contract to the firm?
 [(i) 0.18, (ii) 0.32]

22. If the probability that an individual suffers from reaction of a given medicine is 0.001, determine the probability that out of 2,000 individuals (i) exactly 3 individuals (ii) more than 2 individuals will suffer from reaction.
 [(a) 0.1353, (b) 0.2706, (c) 0.2706, (d) 0.1804]

23. If 2% of the electric bulbs manufactured by a company are defective, find the probability that in a sample of 100 bulbs (a) 1, (b) 1, (c) 2 and (d) 3 bulbs will be defective.
 [0.3601]

24. A certain type of plastic bag in the past has burst under a pressure of 10 pounds 30% of the time. If a prospective buyer tests 5 bags chosen at random, what is the probability that exactly one will burst?
 [0.302]

25. The probability that A will make a profit on any business deal is 0.8, what is the probability that he will make a profit exactly eight times in ten successive deals?

26. The distribution of typing mistakes committed by a typist is given below. Assuming a Poisson model, find out the expected frequencies.

Mistakes per page	0	1	2	3	4	5
No. of pages	142	156	69	27	5	1

(MBA, Sukhadia Univ., 1995)

27. In a normal distribution, 7% of the observations are under 35 and 89% are under 63. What are the mean and the standard deviation of distribution?
 [$\mu = 50.28, \sigma = 10.25$]

28. If the average number of rejects in the manufacturing process of a certain article is 4 per cent, what are the probabilities of 0, 1, 2, 3, 4 rejects in a sample of 40 articles?
 [0.6703, 0.2681, 0.0536, 0.00715, 0.000715]

29. A Municipal Corporation had installed 5,000 bulbs in the streets of the city. 16% of the bulbs have an average life of 800 burning hours, with a standard deviation of 200 hours, find:
 (i) What number of bulbs might be expected to fail in the first 600 burning hours? (ii) The number of bulbs expected to fail between 700 and 900 burning hours, and (iii) The number of bulbs expected to fail after 900 burning hours.
 [(i) 794, (ii) 1915, (iii) 1542.5]

30. The weekly wages of 1,000 workers are normally distributed with a mean of Rs. 1700 and a standard deviation of Rs. 150. Estimate the lowest weekly wages of the 100 highest paid workers.

31. Find the probability that at most 5 defective bolts will be found in a box of 200 bolts, if it is known that 2 per cent of such bolts are expected to be defective. (You may take the distribution to be Poisson.)
 [0.784]

32. If 20% of the bolts produced by a machine are defective, determine the probability that out of 4 bolts (i) 0, (ii) 1 and (iii) at the most 2 bolts will be defective.
 [0.4096, 0.4096, 0.9728]

33. The probability that any customer who enters the store will purchase Colgate toothpaste is 0.3. If 1,000 customers enter the store, what is the minimum number of Colgate toothpastes the store must have on hand, if the probability that it will be out of stock is to be at most 1%?
 [334]

34. Daily demand for a product is approximately normally distributed with mean sales of 12 units per day and standard deviation of 4 units. How many units must be on hand in the morning to assure no more than one chance in 5 of running out of stock during the day?
 [16] (MBA, DU, 2003)

35. The probability that India wins a cricket Test match against England is given to be 1/3. If India and England play three Test matches, use binomial distribution to find the probability that:
 (i) India will lose all three Test matches? (ii) India will win at least one Test match?
 [(i) 0.2963, (ii) 0.7037]

36. An individual is offered an opportunity to bet Rs. 500 on the outcome of a roll of a pair of dice. If the dice turn up so that the sum of the faces total 7 or 11, the individual wins Rs. 1500. For any other outcome the bet is lost. What is the expected value of the game for the individual?

38. The fuel consumption of a fleet of 150 trucks is normally distributed with a mean of 15 km per litre and a standard deviation of 1.5 km per litre. Use normal distribution to find the expected number of trucks that average :
(a) 13 but less than 14 km per litre. (b) 14.5 but less than 15.5 km per litre.

[(a) 24, (b) 39]

39. Fit a Poisson distribution to the data given below :

$X :$	0	1	2	3	4
$f :$	123	59	14	3	1

40. The heights of students in a class are normally distributed with a mean of 62 inches and a standard deviation of 4 inches. What proportion of the students in the class have a height greater than 68 inches? What is the probability that a student selected at random will have a height between 58 inches and 66 inches?

41. One hundred car radio sets are inspected as they come off the production line and number of defects per set is recorded below :

No. of defects :	0	1	2	3	4
No. of sets :	79	18	2	1	0

Fit a Poisson distribution to the above data.

[77.88, 19.47, 2.43, 0.2028, 0.1267]

42. A machine is supposed to drill holes with a diameter of 1.0 inch. In fact, the diameters are normally distributed with a mean of 1.0 inches and a standard deviation of 0.01 inch. If there is a tolerance of 0.02 inch, the holes should be between 0.99 and 1.02 inches. What percentage of the holes drilled are within tolerance limits? (MBA, Delhi Univ., 1999)

43. A hotel maintains two deluxe rooms. The demand for these rooms in any day is distributed as a Poisson distribution with mean 1.5. Calculate the proportion of day on which neither of the rooms would be used; and the proportion of days on which no demand would be refused.

[0.2231, 0.1913]

44. The following frequency table gives the distribution of 1,000 persons according to their income :

Monthly income (Rs.)	No. of persons	Monthly income (Rs.)	No. of persons
Below 5000	16	20000-25000	166
5000-10000	85	25000-30000	100
10000-15000	207	30000-35000	69
15000-20000	346	above 35000	11

Fit a normal distribution to the above frequency table. Also, determine the percentage of persons with an income between 17,500 and 27,500 rupees.

45. A car rental firm has two cars which it rents out day by day. The number of demand for a car on each day is distributed as Poisson distribution with mean 1.5. Calculate the proportion of days on which neither car is used and the proportion of days on which some demand is refused.

46. A dice is thrown 9,000 times and a throw of 3 or 4 is observed 3,240 times. Show that the dice cannot be regarded as an unbiased one and find the limits between which the probability of a throw of 3 or 4 is expected to lie.

47. An automatic detergent packing machine produces packages whose weights are normally distributed with a mean of 8.00 gm and a standard deviation of 0.010 gm.

(a) What proportion of packages are between 7.98 gm and 8.000 gm?

(b) What proportion are between 8.005 and 8.0151 gm?

(c) What proportion are between 7.995 and 8.010 gm?

(d) What proportion are above 8.017 gm?

[(a) 47.72 (b) 24.30 (c) 53.28 (d) 4.46.]

48. A manufacturer of electric fuses packs fuses in boxes of 10 each and 2,000 such boxes were sold. The previous experience shows that 5 per cent of the fuses are defective. Using Poisson distribution, find how many boxes will contain (i) one defective (ii) more than one defective.

49. In a certain factory turning out razor blades, there is a small chance of 1/500 for any blade to be defective. The blades are supplied in packets of 10. Use Poisson distribution to calculate the number of packets containing (i) no defective (ii) one defective and (iii) two defective blades, respectively in a consignment of 10,000 packets.

50. If, on an average 8 ships out of 10 arrive safely at port, find the mean and standard deviation of the number of ships arriving safely out of a total of 1,600 ships.
[$\mu = 1280, \sigma = 16$]

51. Assuming that sex ratio of male children is $\frac{1}{2}$, find the probability that in a family of 5 children, (i) all children will be of the same sex, and (ii) three of them will be boys and two girls.
 [(i) 1/16 (ii) 5/16]
52. A company has 6 telephones which 10 executives use intermittently. Assume that at any given time each executive has the same probability 'p' of requiring to use a telephone. If the executives' requirements of telephones are independent, the probability that exactly k executives require a phone is $b(k, n, p)$. If on an average, an executive uses the telephone for 10 minutes per hour ($p = 1/6$), find the probability that 7 or more executives need a telephone at the same time.
 [0.000267]
53. A machine produces bolts which are 10% defective. Find the probability that in random sample of 400 bolts produced by this machine, the number of defectives found
 (i) will be at most 30;
 (ii) will be between 30 and 50;
 (iii) will exceed 55.
 [(i) 22.8, (ii) 354.32, (iii) 3.56]
54. The mean and standard deviation for the life times of a population of light bulbs are 1200 and 150 hours respectively. Assuming these lifetimes are normally distributed, what is the probability that a light bulb will last over 1500 hours?
 [0.0228]
55. An editor of a publishing company, calculates that it requires 11 months on an average to complete the publication process from manuscript to finished books with a standard deviation of 2.4 months. He believes that the distribution of publication times is well described by the normal distribution. Out of 190 books he will handle this year, how many will complete the process in less than a year?
 [126]
56. An analyst predicts that 2.5% of all small companies will file for bankruptcy in the coming year. For a random sample of 200 companies, estimate probability that
 (i) at least three will file for bankruptcy next year;
 (ii) exactly three will file for bankruptcy;
 (iii) not more than five will file for bankruptcy.
 [(i) 0.87 (ii) 0.145 (iii) 0.6151]
57. Past records show that the average number of accidental drownings at a beach resort is 3 per year for every 100,000 of tourists visiting the resort. If in a year 200,000 tourists visited this resort, find the probabilities that:
 (i) there will be no drowning accident this year;
 (ii) there will be at least 6 accidents this year;
 (iii) there will be exactly 5 accidents this year;
 (iv) there will be more than 8 accidents this year.
 [(i) 0.00279 (ii) 0.498 (iii) 0.1807 (iv) 0.0465]
58. Fit a binomial distribution to the following data:
- | | | | | | |
|----|----|----|----|----|----|
| X: | 0 | 1 | 2 | 3 | 4 |
| f: | 28 | 62 | 28 | 12 | 46 |
- [9.34, 40.48, 65.78, 47.51, 12.86]
59. The financial controller of Galaxy Airlines is having some problems with cash flows. Daily revenue fluctuate greatly and are difficult to predict whereas daily expenses remain fairly constant regardless of the daily number of passengers. If daily revenue has a normal distribution with a mean of Rs. 72,000 and 85 per cent of the values lie below Rs. 82,000, what is the standard deviation of the distribution. What is the value above which 5 per cent of the values in the distribution lie?
60. The following table shows the number of customers returning the products in a marketing territory. The data is for 100 stores:
- | | | | | | | | |
|------------------|---|----|----|----|----|---|---|
| No. of returns : | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| No. of stores : | 4 | 14 | 23 | 23 | 18 | 9 | 9 |
- Fit a Poisson distribution.
 [4.97, 14.91, 22.36, 22.36, 16.77, 10.06, 5.03]
61. Three fair coins are tossed 300 times. Find the frequencies of the distribution of heads and tails and tabulate the result. Also, calculate the mean and standard deviation of the distribution.
 [2.25, 1.06]
62. How many workers have a salary above Rs. 2,675 in the distribution whose average salary is Rs. 2,400 and standard deviation is Rs. 100 and the number of workers in the factory is 15,000, if the salary of workers follows the normal law?
 [1,100]

Jewel's Care Collected

63. The Delhi Municipal Corporation installed 2,000 bulbs in the streets of Kailash Colony. If these bulbs have an average life of 1,000 burning hours, with a standard deviation of 200 hours, what number of bulbs might be expected to fail in the next 700 burning hours?

[134]

64. In 24 trials of an event of small probability, the frequency f of the number of success X is given in the following table.

X	0	1	2	3	4	5	6
f	3	2	6	5	5	1	2

- The mean number of successes is 2.75. Find the expected frequencies of the Poisson distribution with the same mean frequency.

65. The appearing of 2 or 3 on a dice is connected as success. Five dice are thrown 729 times and the following results are observed:

Number of successes	0	1	2	3	4	5
Frequency	45	195	237	132	81	39

Fit the binomial distribution assuming the dice to be unbiased.

66. Five hundred T.V. sets are inspected as they come off the production line and average number of defects per set is found to be 0.402. Find the expected number of T.V. sets having one or more defects.

[165.5]

67. The time required by bank cashier to deal with a customer has been observed to be normally distributed with mean 25 secs and a standard deviation 10 secs. Find the probability that a customer arriving at random will have to wait:

- (i) between 20 and 28 secs. ;
(ii) less than 23 secs.

To what value should the mean service time be altered so that only 1 customer in 100 has to wait longer than 50 secs.?

(i) 0.3094 (ii) 0.4207, 26.7

68. The marks obtained by the students in an examination are known to be normally distributed. If 10% of the students got less than 40 marks while 15% got over 80, what is the mean and standard deviation of marks?

[$\mu = 62.0688$, $\sigma = 17.2413$]

69. In a certain examination, 10% of the students got less than 30 marks and 97% of the students got less than 62 marks. Assuming the distribution to be normal, find the mean and standard deviation of the marks.

[$\mu = 42.96$, $\sigma = 10.13$]

70. For a binomial distribution the mean is 4 and variance 2. Find the probability of getting

(i) at least 2 successes.

(ii) at most two successes. (MBA., DU, 2002)

[(i) 0.9648 (ii) 0.1445]

71. The following table gives the numbers of days in a 50 day period in which automobile accidents occurred in a certain part of a city. Fit a Poisson distribution to the data.

No. of accidents	0	1	2	3	4
No. of days	19	18	8	4	1

(18.4, 18.4, 9.2, 3.1, 0.8)

72. In a book, the following frequency of mistakes per page was observed. Fit a Poisson distribution.

No. of mistakes per page	0	1	2	3	4	5
No. of pages	630	160	90	70	30	20

[463, 357, 137, 35, 7, 1]

73. The distribution of monthly income of 4000 employees follows normal distribution with mean Rs. 6000 and standard deviation Rs. 1000 find:

- (i) Number of employees having income more than Rs. 7,000;
(ii) The number of employees having income less than Rs. 5500;
(iii) The least monthly income among the highest paid 100 employees.

74. (a) Proofreading of 200 pages of a book containing 500 pages gave the following results:

No. of mistakes per page	0	1	2	3	4	5
Frequency	113	62	20	3	1	1
Cost per page for checking	1.0	1.5	2.5	3.0	3.5	4.0

(a) Fit a Poisson distribution.

(b) Estimate the total cost of correcting the whole book.

[(a) 109.76, 65.85, 19.15, 3.95, 0.592, 0.0711 (b) 272.139]

75. Which probability distribution is most likely the appropriate one to use for the following data: Binomial, Poisson, Normal?

- (i) The life span of a female born in 1957.
(ii) The number of autos passing through a toll booth.
(iii) The number of defective radios in a lot of 100.
(iv) The water level in a reservoir.

6. A book has 700 pages. The number of pages with various number of misprints is recorded below. Fit a Poisson distribution to the given data :

Number of Misprints X :	0	1	2	3	4	5
Number of Pages with X misprints :	616	70	10	2	1	1

(M.Com., DU, 1999)

7. An insurance salesman sells policies to 5 men, all of an identical age and in good health. According to actuarial tables, the probability that a man of this particular age will be alive 30 years hence is $\frac{2}{3}$. Find the probability that 30 years hence :

- (i) at least 1 man will be alive.
- (ii) at least 3 men will be alive.

(MBA, IGNOU, Dec. 2002)

78. (a) The local authorities in a certain city install 10,000 electric lamps in the streets of the city. If these lamps have an average life of 1000 burning hours with a standard deviation of 200 hours, assuming normality, what number of lamps might be expected to fail in the first 800 burning hours?

(MBA, IGNOU, Dec. 2001)

(b) In certain organisation out of 400 employees 150 are married. Find the probability that exactly 2 of the 3 randomly chosen employees are unmarried. The purchase department has 10 employees. Find the probability that exactly 4 employees of the department are married. (MBA, Bharathidasan Univ., April 2003)

79. In an examination, it is laid down that a student passes if he secures 30% or more marks. He is placed in the first, second or third division according as he secures 60% or more marks, between 45% and 60% marks and marks between 30% and 45% respectively. He gets a distinction in case he secures 80% or more marks. It is noticed from the result that 70% of the students failed in the examination, whereas 5% of them obtained distinction. Calculate the percentage of the students placed in second division (Assume normal distribution).

(MBA, IGNOU, Dec. 2000)

80. A T.V. manufacturer is facing the problem of selecting a supplier of cathode ray tube, which is the most vital component of a T.V. set. Three foreign suppliers, all equally dependable have agreed to supply the tubes. The prices per tube and the expected life of a tube for the three suppliers are as follows :

	Price/Tube	Expected life of tube
Supplier 1	Rs. 800	1500 hrs.
Supplier 2	Rs. 1000	2000 hrs.
Supplier 3	Rs. 1500	3000 hrs.

The manufacturer guarantees its customers that it will replace the T.V. set if the tube fails earlier than 1000 hours. Such a replacement would cost him Rs. 1000/tube, over and above the price of the tube. Can you help the manufacturer to select a supplier?

(MBA, IGNOU, Dec. 2001)

81. (a) A duplicating machine maintained for office use is operated by an office assistant who earns Rs. 50 per hour. The time to complete each job varies according to an exponential distribution with mean 6 minutes. Assume a Poisson input with an average arrival rate of 5 jobs per hour. If an 8 hours day is used as a base, determine the percentage idle time of the machine and the average time a job is in the system. (B.E./B.Tech., Madras Univ., 2003)

(b) In a survey with a sample of 300 respondents, the monthly income of the respondents follows normal distribution with its mean and standard deviation as Rs. 15,000 and Rs. 3,000 respectively. Answer the following :

- (i) What is the probability that the monthly income is less than Rs. 12,000? Also, find the number of respondent having income less than Rs. 12,000.
- (ii) What is the probability that the monthly income is more than Rs. 16,000? Also, find the number of respondents having income more than Rs. 16,000.
- (iii) What is the probability that the monthly income is in between Rs. 10,000 and Rs. 17,000? Also, find the number of respondents having income in between Rs. 10,000 and Rs. 17,000. (MBA, Bharathidasan Univ., Nov. 2002)

(c) The mean weight of a lunch rice pack is 0.255 kg with a standard deviation of 0.025. The random variable weights of the pack follows a normal distribution.

- (i) What is the probability that pack weighs less than 0.280 Kg.?
- (ii) What is the probability that pack weighs more than 0.350 Kg.?
- (iii) What is the probability that the pack weighs between 0.260 Kg. and 0.340 Kg. ? (M.A. Eco., M.K. Univ., 2003)

$$Z_2 = \frac{3,37,500 - 3,40,000}{20,000 / \sqrt{50}} = -0.88$$

For $Z = \pm 0.88$, the corresponding area is 0.3106.

Required prob. = $0.3106 \times 2 = 0.6212$

For $n_2 = 100$

$$Z_1 = \frac{3,42,500 - 3,40,000}{20,000 / \sqrt{100}} = \frac{2,500 \times 10}{20,000} = 1.25$$

$$Z_2 = -1.25$$

For $Z = \pm 1.25$, the corresponding area is 0.3944.

Required prob. = $0.3944 \times 2 = 0.7888$

For $n_3 = 200$

$$Z = \frac{3,42,500 - 3,40,000}{20,000 / \sqrt{200}} = \frac{2,500 \times 14.142}{20,000} = 1.7676$$

$$Z = -1.7676$$

For $Z = \pm 1.7676$ corresponding area is 0.4616.

Required prob. = $0.4616 \times 2 = 0.9232$.

PROBLEMS

I-A : Answer the following questions, each question carries one mark:

- What are the advantages of sampling ?
- Define 'stratified random sampling'.
- Explain probability sampling.
- What is systematic random sampling ?
- What is random sampling ?
- How a stratified sample is selected ?
- What is multi-stage sampling ?
- What are the limitations of sampling ?
- Mention few situations where only sampling technique can be used.
- What are sampling errors ?

I-B : Answer the following questions, each question carries four marks:

- What are the advantages and limitations of random sampling method ? *(M.A. Eco., Madras Univ., 2001)*
 - What are the various advantages of sample studies over population coverage. *(MBA, Bharathidasan Univ., 2001)*
 - Explain any four sampling methods you are aware of. *(MBA, Bharathidasan Univ., 2001)*
 - Explain the concept of sampling distribution with suitable example.
 - What are the various types of sampling ? *(MBA, Bharathidasan Univ., 2001)*
 - Differentiate between 'Sample' and 'population'. Point out their advantages and limitations.
- Point out the importance of sampling in solving business problems. What are the principles on which sampling rests ?
 - "Sampling is necessary under certain conditions". Explain this with illustrative examples.
 - Describe the various methods of sampling and the requisites of a good sample.
 - What is sampling ? Explain the importance of sampling in solving business problems. Critically examine the well known methods of probability sampling and non-probability sampling. *(MBA, DU, 2001)*
 - Define judgment sampling, quota sampling, and convenience sampling. Under what conditions, can each of these be used to advantage ?
 - Distinguish between random sampling and stratified sampling. Suppose it is desired to survey petrol habits of car owners in a particular city. How would you proceed about it ?
 - Point out the differences between a sample survey and a census survey. Under what conditions, are these undertaken ? Explain the law which forms the basis of sampling. *(MBA, DU, 2001)*
 - What do you understand by sampling ? In order to determine a new cost of living index, it is proposed to make a survey of the income and expenditure of 1,000 households in a large city. Describe carefully two methods which might be used to select the sample households.

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10. Suppose you are asked to conduct a survey on the smoking habits of the Delhi University teachers. How will you proceed?
11. "In any sample survey there are many sources of errors. A perfect survey is a myth." Discuss the statement.
12. "Data collected in census are automatically free of errors." Discuss the validity of the statement.
13. Enumerate the various methods of sampling and describe two of them mentioning the situations where each one is to be used.
14. What is the importance of sampling techniques? Describe the various sampling techniques.
15. Explain the concepts of sampling distribution and standard error. Discuss the role of standard errors in large sample theory.
16. Explain the terms 'Random Sample' and the 'Sampling Distribution of a sample statistic'.
17. Find the mean and variance of the sampling distribution of the sample mean. Distinguish between standard deviation and standard error.
18. "There are many different ways of selecting a sample." Describe the important sampling methods pointing out the characteristics of each.
 - (a) Distinguish between sampling and non-sampling errors. What are their sources? How these errors can be controlled?
 - (b) List the probabilistic and non-probabilistic sampling techniques. Explain stratified random sampling technique.
 - (c) Explain with the help of an example, the concept of sampling distribution of a sample statistic and point out its role in managerial decision-making. (MBA, Delhi Univ., 1998)
20. The weight of certain type of a car tyre is normally distributed with a mean of 25 pounds and variance of 3 pounds. A random sample of 50 tyres is selected. What is the probability that the mean of this sample lies between 24.5 and 25.5 pounds?
[0.9586]
21. For a particular brand of T.V. picture tube, it is known that the mean operating life of the tubes is 1,000 hours with a standard deviation of 250 hours. What is the probability that the mean for a random sample of size 25 will be (i) greater than 1,000 hours, (ii) less than 1,000 hours, (iii) between 950 and 1,050 hours?
[0.5, 0.5, 0.6826]
22. An auditor takes a sample of size 36 from a population of 1,000 accounts receivable. The standard deviation of the population is unknown, but the standard deviation of the sample is Rs. 100. If the true mean value of the accounts receivable from the population is Rs. 3000, what is the probability that the sample mean will be (i) more than or equal to Rs. 2800?
23. A manufacturer of razor blades claims that his product will, on the average, give 15 good shaves. Suppose you have five friends who try using one of these razor blades each. The number of shaves reported by your friends are 12, 16, 8, 14 and 10.
 - (a) Find the mean and standard deviation of this sample.
 - (b) Suggest how you might use this sample evidence to dispute or support the advertiser's claim.
24. For a population of size 5, the values of x are 8, 3, 1, 11 and 4. Construct all possible sample of size two and calculate their sample means. Hence, show that the sample mean is the same as population mean.
25. A manufacturer of knitting yarn has established from past experience that the breaking strength of this yarn is normally distributed with a mean of 12 pounds and standard deviation of 1.8 pounds. What is the probability that a sample size of 49 yield a mean of 14.5 pounds or more?
26. Design a simple example of your own to illustrate the use of finite population correction factor by listing your values of some population, finding σ , and then finding the standard deviation of all possible sample of size 3 drawn without replacement. Does the standard deviation of your sample equal σ/\sqrt{n} multiplied by the population correction factor?
27. Two methods of performing a certain task in a manufacturing plant, method A and method B, are under study. The variable of interest is length of time required to perform the task. It is known that the variance of method A is 9 minutes squared and variance of method B is 12 minutes squared. A simple random sample of 35 employees performed the task by method A and independent simple random sample of 35 employees performed the task by method B. The average time required by the first group to complete the task was 25 minutes and the average time for the second group was 23 minutes. What is the probability of observing difference this large, if there is no difference in the true average length of time required to perform the task?
28. An accountant has determined from prior experience that 60 per cent of his client's customers respond to initial requests for confirmation of their account balances. If a simple random sample of 64 customers is sent requests for confirmation, what is the probability that 50 per cent or more will respond?
29. A research group stated that 16 per cent of the firms of a particular type, A increased their market research budgets in the five years preceding the study. For type B firms the figure was 9 per cent.
 - (a) What are the mean and standard deviation of the sampling distribution of the difference between sample proportions based on independent simple random samples of 100 firms from each type?
 - (b) What proportion of the sample differences would be between 0.05 and 0.10?
 - (c) If you took a simple random sample of size 100 from each industry, what is the probability that the difference you would observe would be equal to or less than 0.02?

30. Suppose it is known that 5 per cent of forms processed by a clerical pool contain at least one error. If a simple random sample of 475 forms is examined, what is the probability that the proportion containing at least one error will be between 0.03 and 0.075 ?
31. A manufacturer of pens has determined from experience that 4 per cent of the pens he produces are defective. If a random sample of 400 pens is examined, what is the probability that the proportion defective is between 0.025 and 0.048 ?
32. Marks obtained by a number of students are assumed to be normally distributed with mean 65 and variance 25. If 3 students are taken at random, what is the probability that exactly two of them will have marks over 70 ?
33. A firm produces light bulbs that are known to have a mean life time of 1,200 hours with a standard deviation of 210 hours. What is the probability that a simple random sample of 100 bulbs will yield a mean that falls between 1,140 and 1,260 hours ?
[0.9956]

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Hence, we may conclude with 90 per cent confidence that the population contains between 1.03 and 3.47 per cent in the entire lot.

Illustration 12. In a large consignment of oranges, a random sample of 500 oranges revealed that 65 oranges were bad. Prove that 99.73% of bad oranges in the consignment certainly lie between 8.5% and 17.5%.

Solution. Given that $n = 500$

$$p = \text{number of bad oranges in the consignment} \frac{65}{500} = 0.13, q = 1 - p = 1 - 0.13 = 0.87, z_c = 3$$

$$\text{and } \sqrt{\frac{pq}{n}} = \sqrt{\frac{0.13 \times 0.87}{500}} = 0.015$$

The 99.73% confidence limits for the population proportion of bad oranges in the consignment are given by

$$p \pm 3 \sqrt{\frac{pq}{n}} = 0.13 \pm 3 \times 0.015 = 0.13 \pm 0.045 = 0.085 \text{ and } 0.175$$

Hence, the percentage of bad oranges in the consignment certainly lies between 8.5% and 17.5%.

Illustration 13. 400 labourers were selected at random from a certain city. Their mean income was Rs. 1700 per month with a standard deviation of Rs. 140. Set up 95% confidence limits within which the income of the labour community of the district is expected to lie.

Solution. Given

$$\bar{x} = 1700, \sigma = 140, n = 400 \text{ and } z_c = 1.96$$

$$\sigma_{\bar{x}} = \frac{\sigma}{\sqrt{n}} = \frac{140}{20} = 7$$

Therefore, 95% confidence limits are given by

$$\begin{aligned} \bar{x} \pm z_c \sigma_{\bar{x}} &= 1700 \pm 1.96 (7) = 1700 \pm 13.72 \\ &= 1686.28 \text{ to } 1713.72. \end{aligned}$$

Illustration 14. In an attempt to control the quality of output for a manufacturing plant, a sample of parts is chosen randomly and examined in order to estimate the population proportion of parts that are defective. The manufacturing process operates continuously unless it must be stopped for inspection or adjustment. In the latest sample of 90 parts, 15 defectives are found. Determine the following estimates of π the population proportion defective (a) a point estimate (b) 98 per cent interval estimate.

Solution. (a) Point estimate: $p = \frac{15}{90} = 0.167$

(b) Interval estimate: $\sigma_p = \sqrt{\frac{p(1-p)}{n}} = \sqrt{\frac{(0.167)(0.833)}{90}} = 0.0393$

98 per cent interval estimate shall be given by

$$\begin{aligned} p \pm z_c \sigma_p &= 0.167 \pm 2.33 \times 0.0393 \\ &= 0.167 \pm 0.092 \text{ or } 0.075 \text{ to } 0.259. \end{aligned}$$

Illustration 15. A random sample of 200 consumer accounts at a large brokerage firm is selected for the purpose of estimating the mean number of transactions per year for each customer. The sample mean is 12. Determine 99% confidence interval for the mean number of transactions of all consumer accounts of the firm.

Solution. Using the formula

$$\bar{x} \pm z_c \frac{\sigma}{\sqrt{n}}$$

where,

$$\bar{x} = 43, z_c = 2.58, \sigma = 2.5, n = 200$$

$$43 \pm 2.58 \frac{2.5}{\sqrt{200}} = 43 \pm 0.456 = 42.544 \text{ to } 43.456.$$

PROBLEMS

I-A: Answer the following questions, each question carries one mark:

- What is statistical estimation?
- Distinguish between point estimate and interval estimate.
- What is point estimation?
- What are confidence limits for population mean?
- What are confidence limits for population proportion?
- Name the important properties of a good estimator.
- Give the formula for the method of maximum likelihood of a good estimator.

(MBA, Madurai-Kannur, 2001)
(MA, Eco. M.K. Univ., 1999)

- (viii) Which formula is used for determining confidence limits for difference of two means ?
- (ix) Give the formula for determining sample size for estimating a population mean.
- (x) What are confidence limits for difference of two proportions ?
- (xi) Differentiate between confidence limits and confidence level.
- (xii) Answer the following questions, each question carries four marks:
1. (i) Explain the concept of confidence interval with suitable example.
 - (ii) Briefly explain any two properties of a good estimator.
 - (iii) Describe the desirable properties of a good estimator.
 - (iv) What are confidence limits ? How are they determined ?
 - (v) How sample size is determined ? Explain with the help of an example.
2. What do you understand by estimation ? In what sense, do we consider estimation as a procedure of decision-making ?
 3. (a) What do you mean by 'Statistical Estimation' ? Briefly explain the methodology used for estimating the mean of the population from the mean of the sample.
 - (b) Distinguish clearly between the point estimation and interval estimation. In what way, do we say that an interval estimate is better than a point estimate ?
 4. (a) Explain clearly the desirable properties of a point estimate.
 - (b) What information and assumptions must be given to compute the sample size for an interval estimate of the universe mean ?
 5. What is the difference between 'Statistic' and 'Parameter' ? Explain, with examples, the methods employed for the estimation of population parameters based on sample means, difference of two means, sample proportion and difference of the sample proportions.
 6. What is meant by confidence interval of a population parameter ?
 7. With the help of an example, explain the method of maximum likelihood and point out its significance.
 8. Comment on the statement, "Theoretically speaking, it is possible to have an estimate which is identical with the parameter being estimated. In practice, however, such an estimate is often unnecessary and physically impossible."
 9. (a) Explain clearly the procedure involved in interval estimation.
 - (b) Describe briefly the problems of estimation of population parameter.
 10. Explain the following terms with the help of an example :
 - (i) Confidence limits, (ii) Confidence interval,
 - (iii) Interval estimate, (iv) Confidence coefficients or critical values.
 11. What are the properties of a good estimator ? Prove that the mean of a simple random sample from a given population is an unbiased estimator of the population mean.
 - (a) Explain briefly the properties of a good estimator.
 - (b) Explain the concepts of (i) the power of statistical test, (ii) reliability and validity of measurements.
 12. In a consignment of 1,00,000 tennis balls, 400 were drawn at random and examined. It was found that 20 of these were defective. How many defective balls can you expect in the whole consignment at 95% confidence level ?
 13. A statistics consultant with the association of personnel director was asked to determine what proportion of electrical personnel who change jobs do so because they are bored with their work. A random sample of 400 electrical personnel who had recently changed jobs were enquired, and 200 stated that they changed jobs because of boredom. What are the lower and upper limits of this interval ?
 14. A bank official is interested in knowing the difference between the average amount of money or deposit by customers in two branch banks. A random sample of 35 customers was selected from each branch. The sample means were as follows - Branch A : Rs. 4500; Branch B : Rs. 3250. The two populations are normally distributed with variances $\sigma_1^2 = 760$ and $\sigma_2^2 = 850$. Construct the 95 and 99 per cent confidence interval for $\mu_1 - \mu_2$.
 15. A random sample of 50 persons was interviewed to find their preference between two brands of tea. 35 of the interviewed persons preferred brand A to brand B. Find the 95 per cent confidence interval for the proportion of persons who prefer brand A.
 16. After an intensive advertisement campaign of polish, the manufacturers wanted to know how many of the possible customers had read the advertisement. They selected a random sample of 50 customers and found that only 15 of them had read the advertisement. Find 95 per cent confidence interval for the proportion of customers who had not read the advertisement.
 17. A manufacturer of television picture tubes tested 75 tubes to determine their mean lifetime. The sample yield an average of 4,200 hours with a standard deviation of 430 hours. Use a 95 per cent level of confidence for the interval estimate of the value below which the mean of the population should not fall.

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18. A new drug has been developed for the treatment of a certain disease. A group of 400 patients suffering from the disease were treated with the new drug. Another group of 400 patients were treated with an alternative drug. At the end of the weeks, 320 of the patients receiving the new drug recovered, while 240 of those taking the alternative drug recovered. Construct the 95 per cent confidence interval for the difference in the true proportion of patients who might be expected to respond to the two drugs.
19. A sample of 16 observations has been taken from a population in which the random variable is normally distributed. The sample mean is 50 and the sample standard deviation is 10. Determine a 95 per cent confidence interval for the population mean.
20. A statistician is asked to conduct a survey to determine an estimate of the proportion of the people who favour the recall of a local politician. He is told that his estimate should not differ from the true proportion by more than 2 per cent with 95 per cent confidence. How large should his random sample be to produce an estimate of the proportion satisfying this condition?
21. The wearing quality of a certain type of truck tyre is to be estimated by road testing a sample of the tyres. It is estimated that the standard deviation of wearing quality is 200 km.
- If the maximum allowable sampling error is 600 km, at a 95 per cent level of confidence, what should be the sample size?
 - If the level of confidence were 99 per cent, what would be the appropriate sample size?
 - If the maximum allowable error were 300 km, what would be the appropriate sample size for a 95 per cent level of confidence?
22. In measuring reaction time, a psychologist estimates that the standard deviation is 0.05 seconds. How large a sample of measurements must be taken in order to be 95% confident that the error of his estimate will not exceed 0.01 seconds? [96]
23. A factory is producing 50,000 pairs of shoes daily. From a sample of 500 pairs, 20% were found to be of substandard quality. Estimate the number of pairs that can be reasonably expected to be spoiled in the daily production and assign limits at 5% level of significance. [Between 385 and 1,615]
24. The guaranteed average life of a certain type of electric light bulbs is 1,000 hours with a standard deviation of 125 hours. It is proposed to sample the output so as to insure that 90% of the bulbs do not fall short of the guaranteed average by more than 2.5 per cent. What should be the minimum size of the sample?
25. A random sample of six castings drawn from a universe of 75 castings shows the following weight for each. Compute an interval estimate for μ at 2% level of confidence.
- | | | | | | | |
|---------------|------|------|------|------|------|------|
| Casting No. : | 1 | 2 | 3 | 4 | 5 | 6 |
| Weight (kg) : | 82.9 | 83.5 | 84.1 | 83.6 | 82.5 | 84.4 |
26. In a random sample of 81 items taken from a large consignment, some were found to be defective. If the standard error of the proportion of defective items in the sample is $1/16$, find 95% confidence limits of the percentage of defective items in the consignment.
27. From previous studies, the population standard deviation for a placement test has been determined to be 12.4. The test is scored on a scale of 0 – 100. A placement agency wants to be 90% confident that the average test score of a sample falls within plus or minus 3 points of the population average score. How large a sample should be selected?
28. The foreman of a mining company has estimated the average quantity of ore extracted per shift to be 34.6 tons and the sample standard deviation to be 2.8 tons per shift based upon a random sample of six shifts. Construct 95% and 90% confidence around sample average estimate.
29. The life (in hours) of a 100 watt bulb is known to be normally distributed with standard deviation of 36 hours. A random sample of 15 bulbs yielded the following results :
- | Life in hours | | | | | | | | | | | | | | |
|---------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 2216 | 2237 | 2249 | 2204 | 2225 | 2301 | 2281 | 2263 | 2318 | 2255 | 2275 | 2295 | 2250 | 2238 | 2300 |
- Construct a 95% two sided confidence interval so that the actual mean of the life of bulbs fall within this interval.
30. A machine fills cans with a soft drink beverage and the manufacturer is interested in obtaining a confidence interval estimate of the variance of its fill volume. A random sample of 20 cans yields a sample variance of 0.0225. Construct a two sided 95% confidence interval for variance.
31. A manufacturer is interested in estimating the proportion (p) of acceptable products. Find an upper limit of sample size which would ensure that this estimate does not deviate from the true value by more than 0.04 at 99% level of confidence.
32. In order to test the durability of a new paint, a highway department had test strips painted across heavily travelled roads at 15 different locations. If on the average, the test strips disappeared after they had been crossed by 1,46, 692 cars and with standard deviation 14,380 cars, construct 99% confidence interval for the true average number of cars it will take to wear off.

33. A machine is supposed to drill holes with a diameter of 1 inch. In fact, the diameters are normally distributed with a mean of 1.01 inches and a standard deviation of 0.02 inch. If there is a tolerance of 0.02 inch, the holes should be between 0.91 and 1.02 inches. What percentage of the holes drilled are within clearance?
34. A machine is producing ball bearings with diameter of 0.5 inches. It is known that the standard deviation of the ball bearings is 0.05 inches. A sample of 100 ball bearings is selected and their average diameter is found to be 0.498 inches. Determine the 99 per cent confidence interval.
35. With a sample size of 400, the calculated standard error of mean is 2 with a mean of 120. What sample size would be required so that we could be 95% confident that the population mean is within ± 3.5 of the sample mean?
36. A random sample of 160 people is taken and 120 were in favour of liberalising licensing regulations. With 95% confidence, what proportion of all people are in favour?
37. A sample of 64 men from a population with known standard deviation of height of 2.4 inches gives a mean height of 69.8 inches. Find a 90% confidence interval of μ , the mean height of the men in the population.
[69.3065 to 70.2935]
38. Given a population with a standard deviation of 8.6, What sample size is needed to estimate the mean of the population within ± 0.5 of the sample mean with 99 per cent confidence? (MBA, KU, 2003)

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Jewel's Care Collected

$$z = \frac{22}{\sqrt{\frac{6889}{562} + \frac{6084}{832}}} = \frac{22}{\sqrt{12.258 + 7.1408}} = \frac{22}{\sqrt{19.3988}} = \frac{22}{4.044} = 4.995$$

The computed value of z is greater than the table value of $z = 4.196$. Therefore, reject the null hypothesis. Hence, there is a significant difference between the male and female verbal ability or female student have higher verbal ability.

PROBLEMS

1-A) Answer the following questions, each question carries one mark:

- (i) What is a hypothesis? (MBA, Madurai-Kanungo, Apr. 20)
- (ii) What is Null Hypothesis? (M. Com., Madurai-Kanungo, 20)
- (iii) What is standard error? (MBA, Madurai-Kanungo, Apr. 20)
- (iv) Explain clearly the terms "standard error" and "sampling distribution". (MBA, Madurai-Kanungo, Apr. 20)
- (v) What is type I error? (M.A., Eco., M.K. Univ., Apr. 20)
- (vi) What is type II error? (MBA, Madurai-Kanungo, 20)
- (vii) Differentiate between type I error and type II error? (MBA, Madurai-Kanungo, 20)
- (viii) What are the critical values at 1% and 5% level? (MBA, Madurai-Kanungo, 20)
- (ix) What is degree of freedom? (MBA, Madurai-Kanungo, 20)
- (x) What is understood by large sample? (MBA, Madurai-Kanungo, 20)

1-B) Answer the following questions, each question carries marks four:

- (i) Sum the procedure followed in testing of hypothesis. (M. Com., M.K. Univ., Apr. 20)
 - (ii) Differentiate the following pairs of concepts:
 - (a) Statistic and parameter
 - (b) Null and Alternative hypothesis
 - (c) Type I and Type II error
 - (iii) Explain the different steps in testing hypothesis. (M. Com., M.K. Univ., Apr. 20)
 - (iv) Define the two types of errors in testing a statistical hypothesis. (MBA, Anna Univ., Dec. 20)
 - (v) Explain the difference between two proportions in test of hypothesis. (M. Com., M.K. Univ., Apr. 20)
2. What is test of hypothesis? Discuss various tests of hypothesis for the cases when the size of sample is large.
3. Explain the procedure generally followed in testing of a hypothesis.
4. Describe the various steps involved in testing of hypothesis. What is the role of standard error in testing of hypothesis? (M. Com., IU, 19)
5. Define the standard error of a statistic. How is it helpful in testing of hypothesis and decision-making?
6. What do you understand by null hypothesis and level of significance? Explain with the help of an example. (MBA, IPU, 19)
7. Write short notes on the following:
 - (i) Type I and Type II error
 - (ii) In the hypothesis testing process, what is the importance of null hypothesis?
 - (iii) "In every hypothesis testing, the two types of errors are always present." - If this is true then explain what is the role of hypothesis testing?
8. Explain clearly the procedure of testing hypothesis. Also point out the assumptions in hypothesis testing in large sample. (M. Phil., Kurukshetra Univ., 20)
9. Differentiate the following pairs of concepts:
 - (i) Statistic and parameter
 - (ii) Critical region and acceptance region
 - (iii) Null and alternative hypothesis
 - (iv) One-tailed and two-tailed test
 - (v) Type I and Type II errors
10. There is always a trade off between Type I and Type II errors. Discuss.
11. Intelligence test on two groups of boys and girls gave the following results:

	Mean	S.D.	Sample size
Girls :	75	15	150
Boys :	70	20	250

Is there a significant difference in the mean scores obtained by boys and girls?

(M. Com., Madurai-Kanungo, 2002; MBA, Kanungo, 2002)

19. In a sample of 1000 persons from the village of Himachal Pradesh, 640 are found to be consumers of rice and the rest consumers of wheat. Can it be concluded that both the food articles are equally popular?
20. Random samples of 100 bolts manufactured by machine 'A' and 50 bolts from machine 'B' showed 10 and 6 defective bolts respectively. Is there a significant difference in the performance of the two machines?
21. The mean lifetime of 200 fluorescent light tubes made by a company gave mean lifetime of 1560 hours with a standard deviation of 50 hours. Is it likely that the sample has come from a population with a mean lifetime of 1,500 hours?
22. A soap manufacturer wanted to know what percentage of the citizens of Mumbai use his soap. He conducted a survey and found that out of 500 persons selected at random for the purpose, only 10% use his soap. He spent Rs. 5 lakh on an advertisement campaign to attract more customers. In order to know the result of his campaign he conducted another survey and found that out of 600 persons 15% are using his soap. Do you think that the expenditure has really increased the percentage of citizens of Mumbai using his soap?
23. A machine puts out 20 imperfect articles in a sample of 1000. After the machine is overhauled, it puts out 5 imperfect articles in a sample of 500. Has the machine improved?
24. In North Delhi, out of a random sample of 500 households, 27% declared that they were regular readers of 'Femina'. In South Delhi, the proportion in a sample of 600 was 30%. Is there a significant difference in the two proportions?
25. A firm found with the help of a sample survey of a city (population 900) that 3/4ths of the population consumes things produced by them. The firm then advertised the goods produced and its radius. After one year, a sample of size 1000 reveals that proportions of consumers of the goods produced by the firm is 4/5th. Is this rise significant to indicate that the advertisement was effective?
26. X is a normally distributed random variable. The variance of X is σ^2 and is known. Construct a test criterion to test the hypothesis that the mean of X is equal to μ_0 (μ_0 given constant). Suppose σ^2 was unknown, suggest an unbiased estimator of σ^2 and give (state) the test criterion to be used in this case.
27. A sample of size 400 was drawn and the sample mean was found to be 39. Test whether this sample could have come from a normal population with mean 40 and variance 16 at 5% level of significance.
28. A manufacturer claimed that at least 95% of the equipments which he supplied to a factory conformed to specifications. An examination of a sample of 200 pieces of equipment revealed that 18 were faulty. Test his claim at a significant level (0.05; 0/1).
29. In a certain factory, there are two independent processes manufacturing the same item. The average weight in a sample of 250 items produced from one process is found to be 120 gm with a standard deviation of 12 gm while the corresponding figure in a sample of 400 items from the other process are 124 and 14 gm. Is the difference between the mean weights significant at 1% level of significance?
30. The mean breaking strength of the cables supplied by a manufacturer is 1900 with a standard deviation 100. By a new technique in the manufacturing process, it is claimed that the breaking strength of the cables has increased. In this claim a sample of 50 cables is tested. It is found that the mean breaking strength is 1950. Can we support the claim at 1% level of significance?
31. A sample of 400 male students is found to have a mean height of 171.24 cm. Can it be reasonably regarded as a sample from a large population with mean height 171.17 cm and standard deviation 3.30 cm?
32. Give the requirements for applying Normal Distribution to a problem of testing the significance of single mean. Give the null hypothesis H_0 and describe the procedure of testing H_0 against various possible alternative hypothesis H_1 at 5% level of significance.
Given $\bar{X} = 82$, $n = 10$, $\sigma = 100$, test the hypothesis that $\mu = 80$.
33. In a random sample of 500 persons from town A, 250 are found to be consumers of wheat. In a sample of 400 from town B, 220 are found to be consumers of wheat. Do these data reveal a significant difference between town A and town B so far as the proportion of wheat consumer is concerned?
34. A company produces two makes of bulbs, A and B. 200 bulbs of each make were tested and it was found that make A has mean life of 2560 hours and S.D. 90 hours, whereas make B had 2650 hours mean life and S.D. 75 hours. Is there a significant difference between the mean life of two makes?
(MBA, Kurukshetra Univ., 1992)
35. An equal opportunities committee is conducting an investigation if in comparable jobs, men and women workers are paid identical wages. The following information is obtained on 75 males and 64 females:

	Male	Female
Salary		10,620
Mean (Rs.)	11,530	750
S.D.	780	

Test at 5% level of significance, whether men and women workers are paid identical wages.

29. In a credit co-operative run by a large company it was found that during the past year, a sample of 300 loans issued showed that 37% of the loans were made to women employees. A similar study carried out 5 years ago showed that the percentage of women employees seeking loans was 32%. Do these data give sufficient evidence to conclude that more women employees are seeking loans in the recent year than before.
Use a 5% significance level or test.
30. Data were collected from two cities as regards the starting stipend paid to new management trainees. Do the data give evidence that the stipend paid in city B is significantly more than that in city A? Test at a significance level of 1%.

City	Monthly Stipend (Means)	Sample Standard Deviations	Sample Size
A	Rs. 8,400	Rs. 80	200
B	Rs. 8,600	Rs. 120	175

31. A manufacturer of steel rods considers that the manufacturing is working properly, if the mean length of the rods is 8 inches. The standard deviation of these rods always runs about 0.3 inch. The manufacturer would like to see, if the process is working correctly by taking a random sample of size $n = 36$. There is no indication whether or not the rods may be short or too long.
(a) Establish null and alternative hypothesis for this problem.
(b) Would you use a one-tailed test or a two-tailed test?
(c) If the random sample yields an average length of 8.7 inches, would you accept null hypothesis or alternative hypothesis?
(MBA, Osmania Univ., 1991)

32. A random sample of 400 villages was taken from Dhanbad and the average population per village was found to be 520 with a standard deviation of 45. Another random sample of 400 villages was taken from Muzaffarpur where the average population per village was found to be 505 with a standard deviation of 50. Using an appropriate test of significance, state whether if the difference between the two averages is statistically significant at 5% level.
33. You are given the following information relating to purchases of bulbs from two manufacturers A and B:

Manufacturer	No. of Bulbs bought	Mean life	S.D.
A	100	2950 hrs.	100 hrs.
B	100	2970 hrs.	90 hrs.

- Is there a significant difference in the mean life of two makes of bulbs?
34. A man buys 200 electric bulbs of each of two well-known makes taken at random from stock for testing purposes. He finds that 'Make A' has a mean life of 2,500 hours with a standard deviation of 90 hours and 'Make B' has a mean life of 2,400 hours with a standard deviation of 75 hours. Is there a significant difference in the mean life of these two makes at 5% level of significance?
35. Random samples drawn from two places gave the following data relating to the heights of adult males:

	Place A	Place B
Mean height (in inches)	68.50	65.50
Standard deviation (in inches)	2.5	3.0
No. of adult males in sample	1,200	1,500

- Test at 5% level, that the mean height is the same for adults in the two places.
36. A stock broker claims that he can predict with 80 per cent accuracy whether a stock's market value will rise or fall during the coming month. As a test, he predicts the outcome of 40 stocks and is correct in 28 of the predictions. Does this evidence support the stock broker's claims?
37. Two research laboratories have independently produced drugs that provide relief to arthritis patients. The first drug was tested on a group of 100 arthritis patients and produced an average of 8.5 hours of relief with a standard deviation of 2 hours. The second drug was tested on 75 patients, producing an average of 7.8 hours of relief with a standard deviation of 1.5 hours. At a significance level of 1 per cent, does the first drug provide a significantly longer period of relief?
38. In a simple random sample of 600 men taken from a big city, 450 are found to be smokers. In another simple random sample of 900 men taken from another city, 450 are smokers. Do the data indicate that there is a significant difference in the habit of smoking in the two cities?

39. An auto company decided to introduce a new six cylinder car whose mean petrol consumption is claimed to be lower than that of the existing auto engine. It was found that the mean petrol consumption for the 50 cars was 14 km per litre with a standard deviation of 3.5 km. per litre. Test for the company at 5% level of significance, whether the claim, the new car petrol consumption is 13.5 km per litre on the average is acceptable.
40. The management of a company claims that the average weekly income of their employees is Rs. 900. The trade union disputes this claim stressing that it is rather less. An independent survey of 150 randomly selected employees estimated the average to be Rs. 856 and the Standard Deviation to be Rs. 364.26. Would you accept the view of the management or the trade union ?
41. Two brands of bulbs are quoted at the same price. A buyer tested a random sample of 100 bulbs of each brand and found the following :

	Mean life (hrs)	S.D. (hours)
Brand I	1300	82
Brand II	1248	83

Is there a significant difference in the quality of two brands of bulbs at 5% level of significance ? (MBA, DU, 1999)

[4.45]

42. (a) In two large populations, there are 30% and 25% fair coloured people, respectively. Is this difference likely to be hidden in samples of 1200 and 900 respectively from the two populations ? (Given, the tabulated value of test statistics at 5% level of significance is 1.96) (MBA, IGNOU, June 2001)
- (b) A filling machine at a soft drink factory is designed to fill bottles of 200 ml with a standard deviation of 10 ml. A random sample of 50 filled bottles was taken and the average volume of soft drink was computed to be 198 ml per bottle. Test the hypothesis that the mean volume of soft drink per bottle is not less than 200 ml at 5% level of significance.

(MBA, IGNOU, June 2002)

Jewel's Care Collected

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Solution. Let us take the hypothesis that there is no significant difference in the mean scores because of different texts. Applying t -test of difference of means :

$$t = \frac{\bar{x}_1 - \bar{x}_2}{s} \sqrt{\frac{n_1 n_2}{n_1 + n_2}}$$

$$s = \sqrt{\frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}} = \sqrt{\frac{(12 - 1)8^2 + (15 - 1)9^2}{12 + 15 - 2}}$$

$$= \sqrt{\frac{704 + 1400}{25}} = \sqrt{\frac{2104}{25}} = 9.14$$

$$t = \frac{72 - 18}{9.17} \sqrt{\frac{12 \times 15}{12 + 15}} = \frac{-6}{9.17} \times 2.58 = -1.69$$

For $\nu = 25, t_{0.05} = 2.06$.

The calculated value of t is less than the table value. Hence, there is no significant difference in the mean scores of these instructors.

Illustration 24. The average middle class family spends Rs. 9,000 monthly. Assume a random sample of 25 families in a city, showed a sample mean monthly expenditure of Rs. 8,450 with a standard deviation of Rs. 1,450. Test $H_0: \mu = \text{Rs. } 9,000$ vs $H_a: \mu \neq \text{Rs. } 9,000$ with $\alpha = 0.05$. Use Two Tailed test.

(i) What are the critical values of the test statistic, and what is the rejection region?

(ii) Compute the value of the test statistic.

(iii) What is your conclusion?

Solution. Given $\mu = 9000, n = 25, \bar{x} = 8450, s = 1450$

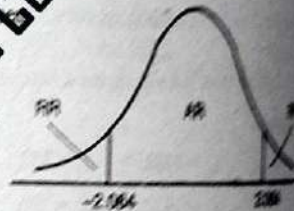
Let us take the null hypothesis that there is no significant difference between the sample mean monthly expenditure and population monthly expenditure, i.e.,

$H_0: \mu = \text{Rs. } 9000, H_a: \mu \neq \text{Rs. } 9000$, Using t -test.

(i) Critical values of t for 24 df . at 5% level of significance are ± 2.064 .

$$(ii) t = \frac{\bar{x} - \mu}{s / \sqrt{n}} = \frac{8450 - 9000}{1450 / \sqrt{25}} = \frac{-550 \times 5}{1450} = -1.897$$

(iii) Since the computed value of $t = -1.897$ is less than the table value of $t = -2.064$, therefore, it lies in the acceptance region. Hence, there is no significant difference between sample mean monthly expenditure and population mean monthly expenditure. Therefore, the samples have been drawn from the given population.



PROBLEMS

1-A : Answer the following questions, each question carries one mark:

- What is a t -distribution?
- Write the formula for difference of two means in case of small sample tests.
- Define t -test.
- Give two important properties of t -distribution.
- Give at least two important applications of t -distribution.
- What do you understand by degrees of freedom?
- What is paired t -test? Give its formula.
- What is F -distribution?
- Give two important properties of F -distribution.
- Give any important application of F -distribution.

(MBA, Madurai-Kamraj Univ., April 2011)

(M. Com., Madurai-Kamraj Univ., 2011)

1-B : Answer the following questions, each question carries four marks:

- Explain the difference between the means of two samples by using t -distribution.
- Explain t -test distribution and note its properties.
- In what ways small sampling theory differs from large sampling theory.
- What is the procedure involved in testing hypothesis of a coefficient of correlation.
- What are the assumptions involved in using the F -test for testing the equality of two sample variances?

(M. Com., M.K. Univ., April 2011)

- How does small sampling theory differ from large sampling theory ?
- (a) What is t -distribution ? Give its important properties.
- (b) What is Students ' t ' distribution? Point out its usefulness.
- (c) Give some important applications of the t -test and explain how it helps in arriving at business decisions.
- (d) How can ' t ' test be applied for testing the significance of the difference between two sample means ?
- Discuss the F -test for testing the equality of two sample variances. State clearly assumptions involved.

(MBA, Kumoun Univ., 2002)

11. 12 persons were appointed in clerical position in an office. Their performance was noted by giving a test and the marks recorded out of 10. They were given 3 month's training and again they were given a test and marks recorded out of 12.

Employees	: A	B	C	D	E	F	G	H	I	J	K	L
Before training	: 4	5	3	7	8	6	5	9	10	6	4	3
After training	: 5	4	6	8	7	5	9	9	10	8	5	4

Can it be concluded that the training has improved the performance of the employees ?

12. A random sample of 25 pairs of observations from a normal population gives a correlation coefficient of 0.46. Is it likely that the variables in the population uncorrelated ?

13. A random sample of 10 boys had the following I.Q.'s : 75, 80, 110, 101, 88, 83, 95, 98, 107, 100. Do these data support the assumption of a population mean I.Q. of 100? Find a reasonable range in which most of the mean I.Q. values of samples of 10 boys lie.

14. Two laboratories A and B carry out independent estimates of fat content in ice-cream made by a firm. A sample is taken from each batch, halved and the separate halves sent to the two laboratories. The fat content obtained by the laboratories is recorded below :

Batch No.	: 1	2	3	4	5	6	7	8	9	10
Lab. A	: 3	5	7	3	8	6	9	4	7	8
Lab. B	: 9	8	8	4	7	7	9	6	6	6

Is there a significant difference between the mean fat content obtained by the two laboratories A and B ?

15. An automobile tyre manufacturer claims that the average life of certain grade of tyre is greater than 25,000 km when used under normal driving conditions on a car of a certain weight. A random sample of 15 tyres was tested, and a mean and standard deviation of 27,000 and 5,000 kms respectively, were computed. Can we conclude that the manufacturer's product is as good as claimed ?

(M. Com., Moduraj-Kamaraj, 2002)

($t = 1.55$)

16. The quality control department of a food processing firm specifies that the mean net weight per package of a certain food must be 20 gms. Experience has shown that the weights are approximately normally distributed with a standard deviation of 15 gms. If a random sample of 15 packages yields a mean weight of 19.5 gms, is this sufficient evidence to indicate that the true mean weight of the package has decreased ?

(MBA, Delhi Univ., 1995)

($t = 1.29$)

17. Two working designs are under consideration for adoption in a plant. A time and motion study shows that 12 workers using design A have mean assembly time of 300 seconds with a standard deviation of 12 seconds and that 15 workers using design B have a mean assembly time of 335 seconds with a standard deviation of 15 seconds. Is the difference in the mean assembly time between the two working designs significant at 1% level of significance ?

(MBA, Delhi Univ., 1994)

($t = 23.52$)

18. The mean life of a sample of 10 electric light bulbs was found to be 1,456 hours with standard deviation of 423 hours. A second sample of 17 bulbs chosen from a different batch showed a mean life of 1,280 hours with standard deviation of 398 hours. Is there a significant difference between the means of the two batches ?

(MBA, Kumoun Univ., 2002)

($t = 1.085$)

19. The variability in the tensile strength of two types of steel wire is to be compared. Given a sample of 14 observations of type A wire yielding a variance of 31.5, and a sample of 15 observations of type B wire yielding a variance of 29.3. Test the hypothesis that the two populations have equal variances.

20. In an F ratio with $v_1 = 4$ and $v_2 = 15$ is found to be 3.64. Is this value of F , significantly different from zero at 5% level of significance ?

21. A sample of the monthly earnings records of 15 employees of company A has a variance of Rs. 15.90, while a similar sample of 87 employees for company B has a variance of Rs. 17.50. Is it safe to assume that there is less variance in company A than in company B ?

538 Business Statistics

17. The nicotine contents in milligrams of two samples of tobacco were found to be as follows :

Sample A :	20	16	26	27	23	22	
Sample B :	27	33	42	35	32	34	38

Can it be said that two samples come from normal population having the same mean ? (MBA, Sukhadia Univ., 1998)

18. Two laboratories carry out independent estimates of a particular chemical in a medicine produced by a certain firm. A sample is taken from each batch, halved and the separate halves sent to the two laboratories. The following data are obtained :

Number of samples	10
Mean value of the difference of estimates	0.6
Sum of the squares of the differences (from their means)	20

Is the difference significant ?

19. A fertiliser mixing machine is set to give 12 kg of nitrate for every quintal bag of fertiliser. Ten 100 kg bags are examined. The percentage of nitrate are as follows :

11, 14, 13, 12, 13, 12, 13, 14, 11, 12.

Is there reason to believe that the machine is defective ?

(MBA, Delhi Univ., 1999)

20. The marks obtained by two groups of students in a Statistics test are given below :

	Group A	Group B
No. of students	12	11
Mean Marks	42	38
Standard Deviation of Marks	10	15

On the basis of this data, can it be concluded that there is a significant difference in the mean marks obtained by the two groups ?

21. Two types of batteries are tested for their length of life and the following data are obtained :

	Size of sample	Mean life in Hours	Variance
Type A	9	600	400
Type B	8	640	44

Is there a significant difference in the two means ?

[$t = 7.17$]

(MBA, DU, 1997)

22. A correlation coefficient of 0.2 is found in a sample of 28 pairs. Use Z-test to find out if this is significantly different from zero.

23. Two different types of drugs 'A' and 'B' were tried on certain patients for increasing weight, 6 persons were given drug A and 8 persons were given drug B. The increase in pounds is given below :

Drug A	7	10	13	12	4	8		
Drug B	12	8	3	18	16	9	8	3

Do the two drugs differ significantly with regard to their effect in increase in weight ?

[$t = 0.42$]

24. The mean weekly sales of the chocolate bar in general stores was 146.3 bars per store. After an advertising campaign, the mean weekly sales in 22 stores for a typical week increased to 157.7 bars and showed a standard deviation of 17.2. Was the advertising campaign successful ?

25. A company desires to compare the effects on cavities of its brand A with a competitor's brand B. To eliminate some of the variation in test population pairs of identical twins are used. A brand is randomly assigned to each twin and is used for two years. The number of cavities developed during the period are reported below :

Pair	1	2	3	4	5
Brand A	4	5	7	6	3
Brand B	3	5	4	2	1

Test at 5% level of significance, whether the data indicate a difference in cavities developed between the two brands.

26. Calculate the value of t and test the hypothesis of the difference between the average proteins for the two States as given below :

	Protein results						
State I	12.6	13.4	11.9	12.8	13.0		
State II	13.1	13.4	12.8	13.5	13.3	12.7	12.4

27. As a part of an industrial training programme, some trainees are instructed by method A, which is straight teaching machine instruction, and some are instructed by method B, which involves the personal attention of the instructor. The trainees instructed by each method, and the scores they obtained in an appropriate achievement test are :

Method A : 71 75 65 69 73 66 68 71 74 68
 Method B : 72 77 84 78 69 70 77 73 65 75

Test the claim that method B is more effective. Use 5% level of significance.

[$t = 1.977$]

28. Two independent samples of 8 and 7 items respectively gave the following values :

Sample A : 9 11 13 11 15 9 12 14
 Sample B : 10 12 10 14 9 8 10

Examine, whether the difference between the means of the two samples is significant?

29. To test the effect of a fertiliser on rice production, 24 plots of land having equal areas were chosen. Half of these plots were treated with fertiliser and the other half were untreated. Other conditions were the same. The mean yield of rice on the untreated plots was 4.8 quintals with a standard deviation of 0.4 quintal, while the mean yield on the treated plots was 5.1 quintals with a standard deviation of 0.26 quintal. Can we conclude that there is significant improvement in rice production because of the fertiliser at 5% level of significance?

[$t = 2.18$]

30. To compare the efficiency of standard and electric typewriters, ten typists are chosen at random and trained in the use of both kinds of typewriters. They are then asked to type on each kind of typewriter for half an hour and their speeds measured average number of words typed per minute, are observed and given in the table below :

Typist	A	B	C	D	E	F	G	H	I	J
Standard	60	64	72	76	75	75	79	74	84	82
Electric	56	62	70	90	70	72	78	70	90	100

Are you of the opinion that there is a vast difference in the efficiency of the two types of typewriters?

Suppose your company decides to buy the standard typewriter for use only when the electric typewriter gives 20 words per minute greater than that of a standard typewriter. Based on the result obtained above, how should the company act?

31. In an assignment, subjects were assigned at random between two conditions, five to each. Their scores are given below. Can one say that there is a significant difference between these two conditions? What must be assumed in carrying out this test?

Condition A :	128	115	120	110	103
Condition B :	123	115	130	135	113

32. A company selects 9 salesmen at random and their sales figures (in thousand Rs.) for the previous month are recorded. They then undergo a course devised by a business consultant and their sales figures for the following month are compared as shown in the table. Has the training course caused an improvement in the salesmen's ability? Use 5% level.

Previous month :	75	90	94	85	100	90	69	70	64
Following month :	77	101	93	92	105	88	73	76	68

[$t = 3$]

33. Two random samples were drawn from two normal populations and their values are :

A :	66	67	75	76	82	84	88	90	92
B :	64	66	74	78	82	85	87	92	95

Test, whether the two populations have the same variance at 5% level of significance.

[$F = 1.415$]

34. The lifetime of electric bulbs for a random sample of 10 from a large consignment gave the following data :

Sample	1	2	3	4	5	6	7	8	9	10
Life in 1000 hours :	4.2	4.6	3.9	4.1	5.2	3.8	3.9	4.3	4.4	5.6

Can we accept the hypothesis that the average lifetime of bulbs is 4000 hours?

35. A sample of 25 college students is given an aptitude test. The mean test score for the sample is 475 and the standard deviation is 30. It is believed that the students of the college are above the normal average test score of 470. Conduct an appropriate test at 5% level of significance.

36. A drug is given to 10 patients, and the increments in their blood pressure were recorded to be 3, 6, -2, 4, -3, 4, 6, 0, 0, 2. Is it reasonable to believe that the drug has no effect on change of blood pressure?

37. A machine is producing ball bearings with diameters of 0.5 inches. It is known that the standard deviation of the bearings is 0.005 inches. A sample of 25 ball bearings is selected and their average diameter is found to be 0.498 inches. Determine the 99 per cent confidence interval.

38. Ten students are selected at random from a college and their height (in cms.) are found to be 100, 104, 108, 110, 114, 118, 122, 124, 126 and 128 cms. In the light of these data, discuss the suggestion that the mean height of the students of the college is 110 cms. (Use 5% level of significance).

[$t = 1.936$]

39. For a random sample of 10 persons, fed on diet A, the increases in weight in pounds in a certain period were :

10 6 16 17 13 12 8 14 15 9

For another random sample of 12 persons, fed on diet B, the increases in weight in the same period were :

9 13 22 15 12 14 18 8 21 13 10 17

Test, whether the diets A and B differ significantly as regards their effect on increase in weight.

40. The wages of 10 workers taken at random from a factory are given below :

Wages (Rs.) : 1578, 1572, 1570, 1568, 1572, 1578, 1570, 1572, 1596, 1584.

Is it possible that the mean wage of all workers of this factory is Rs. 1580 ?

[$t = 1.431$, yes]

41. Eight students were given a test in mathematics and after one month's coaching, they were given another test of the similar nature. The following table gives the increases in their marks in the second test over the first :

Roll No.	1	2	3	4	5	6	7	8
Increase in marks	4	-2	6	-8	12	5	-7	2

Do the marks indicate that the students have gained from coaching ?

42. 10 workers are selected at random from a large number of workers in a factory. The number of items produced by them on a certain day are found to be :

51, 52, 53, 54, 55, 56, 57, 58, 59, 60.

In the light of these data, would it be appropriate to suggest that the mean of the number of items produced in the population is 58 ?

[$t = 2.6$, yes]

43. An automatic device is set to fill 170 pills in each bottle of a certain medicine. A sample of ten bottles was taken. They were found to contain : 168, 164, 166, 167, 168, 169, 170, 170, 170 and 171 pills, with a standard deviation of 2.16 pills. Discuss whether the device is properly adjusted.

44. A random sample of 9 items is taken of a certain measurement. From the data, it is found that $\Sigma X = 108$ and $\Sigma X^2 = 1344$. Find the confidence limits for the population mean at 5% level of significance and test the hypothesis that the population mean is 8. (Table values of 't' at 5% level for 8 d.f. and 9 d.f. are respectively 2.306 and 2.262.)

45. The following data show weekly sales of a manufacturer before and after reorganisation of the sales function, 10 weeks from Sept. to Dec. in the successive years were selected for comparisons :

Week No.	1	2	3	4	5	6	7	8	9	10
Sales (before re-organisation) (in '000 Rs.)	15	17	12	18	16	13	15	17	19	18
Sales (after re-organisation) (in '000 Rs.)	20	19	18	22	20	19	21	23	24	24

Apply 't' test to determine whether reorganisation had any effect on sales.

(MBA, Lucknow, 198)

46. Eleven sales executives trainees are assigned selling jobs right after their recruitment. After a fortnight, they are withdrawn from their field duties and given a month's training for executive sales. Sales executed by them in thousands of rupees before and after the training in the same period, are listed below :

Sales ('000 Rs.)												
(Before training)	:	23	20	19	21	18	20	18	17	23	16	19
Sales ('000 Rs.)												
(After training)	:	24	19	21	18	20	22	20	20	23	20	27

Do these data indicate that the training has contributed to their performance? (M.Com., DU, 1999; M.Com., AMU, 200)

47. (a) Road testing of a random sample of cars was carried out to determine if mean mileage is greater for model I cars than model II. The sample data for model I: $n_1 = 8$, $\bar{x}_1 = 26.3$ and $s_1 = 1.4$, model II: $n_2 = 10$, $\bar{x}_2 = 23.6$ and $s_2 = 1.2$. Test the null hypothesis. Perform a hypothesis test at 5% level and interpret the results.

(MBA, M.D. Univ., 200)

(b) Two types of drugs were used on 5 and 7 patients for reducing their weights.

Drug A : 10 12 13 11 14
 Drug B : 8 9 12 14 15 10 9

Is there a significant difference in the efficacy of the two drugs? If not which drug should you buy?

(M. Com., Madurai Kamaraj, 2002)

48. Two random samples gave the following results :

Sample	Size	Sample mean	Sum of squares of deviations from mean
1	10	15	90
2	12	14	108

Assuming normal population, test for the equality of population at 5% level of significance. (MBA, IGNOU, June 2002)

49. Twelve children, each one selected from 12 sets of identical twins were trained by a certain method A and the remaining 12 children were trained by method B. At the end of the year, the following I. Q scores were obtained :

Pair : 1 2 3 4 5 6 7 8 9 10 11 12
 MethodA : 124 118 127 120 135 130 140 128 140 126 130 126
 MethodB : 131 127 135 128 137 131 132 125 141 118 132 129

Is this a sufficient evidence to indicate a difference in the average I. Q scores of the two groups? (MBA, Anna Univ., 2003)

50. In a certain experiment to compare two types of food A and B, the following results of increase in weights are observed in subjects :

Subject →		1	2	3	4	5	6	7	8	Total
Increase	Food A	49	53	51	52	47	50	52	53	407
in weight	Food B	52	55	52	53	50	54	54	53	423

Assuming that the two samples of subjects are independent, can we conclude that Food B is better than Food A in promoting weight gain? (MBA, IGNOU, Dec., 2001)

51. A vending machine is supposed to discharge 8 ounces of coffee if the correct coins are inserted. To test whether the machine is operating properly, 16 cups of coffee are taken from the machine and measured. It is found that the mean and standard deviation of 16 measurements are 7.5 and 0.8 ounces respectively. Is the machine operating properly? (M. Com., Allahabad Univ., 2001)

52. Two designs A and B gave the following output in 9 trials of each, which is a better design. Why?

Output
 A : 16 16 53 15 31 17 14 30 20
 B : 18 27 23 21 22 26 39 17 28

(MBA, Bharathidasan Univ., 2003)

Jewel's Care Collected

For $\nu = 5, \chi^2_{0.10} = 9.24$

The calculated value of χ^2 is greater than the table value. Therefore, we reject the null hypothesis. Hence, Poisson distribution does not provide good fit to the given data.

Illustration 28. In setting sales targets, the marketing manager makes the assumption that order potentials are the same for each of the four sales territories. A sample of 200 sales data is given below :

Sales Territories			
I	II	III	IV
60	45	59	36

Should the manager's assumption be rejected.

(MBA, D.U., Oct. 2003)

Solution. Let us take the null hypothesis that the order potentials are the same for each of the four sales territories. Hence, the expected sales target should be, i.e., 50 in each sales territory. Applying χ^2 test :

O	E	(O - E) ²	(O - E) ² /E
60	50	100	2.00
45	50	25	0.50
59	50	81	1.62
36	50	196	3.92
			$\Sigma [(O - E)^2/E] = 8.04$

$$\chi^2 = \Sigma \frac{(O - E)^2}{E} = 8.04$$

For $\nu = 3, \chi^2_{0.05} = 7.81$

The calculated value of χ^2 is more than the table value. Hence, the null hypothesis is rejected. We, therefore, conclude that the order potential is not the same for each of the four sales territories.

Illustration 29. The following table gives the number of aircraft accidents that occurred during the various days of the week. Test, whether the accidents are uniformly distributed over the week.

Days	Mon.	Tue.	Wed.	Thurs.	Fri.	Sat.
No. of accidents	14	18	12	11	15	14

(MBA, IGNOU, Dec. 2000)

Solution. Let us take the null hypothesis that the accidents are uniformly distributed over the week. Applying χ^2 test :

Days	O	E	(O - E) ²	(O - E) ² /E
Mon.	14	14	0	0.000
Tue.	18	14	16	1.143
Wed.	12	14	4	0.286
Thurs.	11	14	9	0.643
Fri.	15	14	1	0.071
Sat.	14	14	0	0.000
			$\Sigma [(O - E)^2/E] = 2.143$	

$$\chi^2 = \Sigma \frac{(O - E)^2}{E} = 2.143$$

For $\nu = 5, \chi^2_{0.05} = 11.07$. The calculated value is much less than the table value. The null hypothesis is accepted. We therefore, conclude that the accidents are uniformly distributed.

PROBLEMS

1-A : Answer the following questions, each question carries one mark:

- (i) In contingency table, which of the following determines the degrees of freedom.
(a) $(r - 1)(c - 1)$, (b) $(r - 1)(c + 1)$, (c) $(r + 1)(c + 1)$, (d) $(r - 1)(c + 1)$
- (ii) Define χ^2 distribution.
- (iii) What is χ^2 test of goodness of fit ?

(MBA, Madurai-Kamaraj, Nov. 2003)

(M. Com., Madurai-Kamaraj, 2003)

(M. Com., M.K. Univ., Nov. 2003)