14.1.1 What conclusion would be appropriate for an upper-tailed chi-squared test in each of the following situations?

a. $\alpha = .05, df = 4, \chi^2 = 12.25, \chi^2_{0.05,4} = 9.488$. Reject null hypothesis

b. $\alpha = .01, df = 3, \chi^2 = 8.54, \chi^2_{0.01,3} = 11.344$. Fail to reject null hypothesis

c. $\alpha = .10, df = 2, \chi^2 = 4.36, \chi^2_{0.1,2} = 4.605$. Fail to reject null hypothesis

d. $\alpha = .01, k = 6, \chi^2 = 10.20, \chi^2_{0.01,6-1} = 15.085$. Fail to reject null hypothesis

14.1.7 Criminologists have long debated whether there is a relationship between weather conditions and the incidence of violent crime. The author of the article **"Is There a Season for Homicide?" (*Criminology*, 1998: 287–298)** classified 1361 homicides according to season, resulting in the accompanying data. Test the null hypothesis of equal proportions using $\alpha = .01$.

Winter	Spring	Summer	Fall
328	334	372	327

$\alpha = 0.01, n = 1361, H_0: p_1 = p_2 = p_3 = p_4 = 0.25, H_a$: At least one of the p_i 's is different. $E = np = 1361(0.25) = 340.25$

Distribution	Observation	E	O – E	(O – E)^2	(O – E)^2/E
0.25	328	340.25	–12.25	150.0625	0.441
0.25	334	340.25	–6.25	39.0625	0.1148
0.25	372	340.25	31.75	1008.0625	2.9627
0.25	327	340.25	–13.25	175.5625	0.516

$$\chi^2 = \sum \frac{(O-E)^2}{E} = \frac{150.0625 + 39.0625 + 1008.0625 + 175.5625}{340.25} = 4.0345$$

The P-value is the probability of obtaining the value of the test statistic, or a value more extreme. The P-value is the number (or interval) in the column title of the chi-square distribution table in the appendix containing the χ^2 value in the row $df = c - 1 = 4 - 1 = 3$: $0.10 < P < 0.90$. If the P-value is less than or equal to the significance level, then the null hypothesis is rejected. $\chi^2_{0.01,3} = 11.344$. Because P-value > 0.01, we fail to reject H_0. There is not sufficient evidence to reject the claim of equal proportions.

14.2.13 A study of sterility in the fruit fly **("Hybrid Dysgenesis in *Drosophila melanogaster*: The Biology of Female and Male Sterility," *Genetics*, 1979: 161–174)** reports the following data on the number of ovaries developed by each female fly in a sample of size 1388. One model for unilateral sterility states that each ovary develops with some probability p independently of the other ovary. Test the fit of this model using χ^2.

***x* = Number of Ovaries Developed**	0	1	2
Observed Count	1212	118	58

$$p(0) = (1-p)^2, p(1) = 2p(1-p), p(2) = p^2$$

$$L \propto ((1-p)^2)^{1212} \cdot \left(p(1-p)\right)^{118} (p^2)^{58} = p^{234}(1-p)^{2542}, LL = C + 234 \ln p + 2524 \ln(1-p)$$

$$\frac{\partial LL}{\partial p} = \frac{234}{p} - \frac{2542}{1-p} = 0 \to 2542p = 234 - 234p, \hat{p} = \frac{234}{2542 + 234} = 0.843$$

$$\hat{\theta} = \frac{n_1 + 2n_2}{2(n_0 + n_1 + n_2)} = \frac{n_1 + 2n_2}{2n} = \frac{118 + 2(58)}{2(1388)} = 0.0843$$

$$n\pi_0\hat{\theta} = 1388(1 - 0.0843)^2 = 1163.86, n\pi_1\hat{\theta} = 1388(2)(0.0843)(1 - 0.0843) = 214.28, n\pi_2\hat{\theta} = 1388(0.0843^2) = 9.86$$

$$\chi^2 = \frac{(1212 - 1163.86)^2}{1163.86} + \frac{(118 - 214.28)^2}{214.28} + \frac{(58 - 9.86)^2}{9.86} = 280.204$$

df = 4 – 1 – 1 = 2, $\chi^2_{0.05,2} = 5.992$. Reject H_0.

14.3.27 The article **"Human Lateralization from Head to Foot: Sex-Related Factors" (*Science*, 1978: 1291–1292)** reports for both a sample of right-handed men and a sample of right-handed women the number of individuals whose feet were the same size, had a bigger left than right foot (a difference of half a shoe size or more), or had a bigger right than left foot.

	L > R	**L = R**	**L < R**	**Sample Size**
Men	2	10	28	40
Women	55	18	14	87

Does the data indicate that gender has a strong effect on the development of foot asymmetry State and test the appropriate hypotheses.

$\alpha = 0.05, H_0$: The variables are independent, H_a: The variables are dependent.

O	E = np	O – E	$(O - E)^2$	$(O - E)^2/E$
2	17.9528	–15.9528	254.4904	14.1756
10	8.8189	1.1811	1.395	0.1582
28	13.2283	14.7717	218.2017	16.495
55	39.0472	15.9528	254.4904	6.5175
18	19.1811	–1.1811	1.395	0.0727
14	28.77	–14.7717	218.2017	7.5839

$$\chi^2 = 14.1756 + 0.1582 + 16.495 + 6.5175 + 0.0727 + 7.5839 = 45.0029$$

$df = (r-1)(c-1) = (2-1)(3-1) = 2, \chi^2_{0.05,2} = 5.992$. If the *P*-value is less than or equal to the significance level, then the null hypothesis is rejected. There is sufficient evidence to support the claim of an association between the variables.

14.3.36 Consider the accompanying 2 × 3 table displaying the sample projection that fell in the various combinations of categories (e.g., 13% of those in the sample were in the first category of both factors).

	1	**2**	**3**
1	.13	.19	.28
2	.07	.11	.22

a. Suppose the sample consisted of *n* = 100 people. Use the chi-squared test for independence with significance level .10.

$\alpha = 0.10, H_0: p_{ij} = p_{i\cdot} \cdot p_{\cdot j}, H_a$: H_0 is not true.

	1	**2**	**3**	
1	12	18	30	60
2	8	12	20	40
	20	30	50	100

$$\chi^2 = \frac{1}{12} + \frac{1}{18} + \frac{4}{30} + \frac{1}{8} + \frac{1}{12} + \frac{4}{20} = 0.68, df = (2-1)(3-1) = 2, \chi^2_{0.1,2} = 4.605$$

Fail to reject null hypothesis at given significance level. Conclude that there is effect.

b. Repeat part (a), assuming that the sample size was *n* = 1000.

$\chi^2 = 0.6806(10) = 6.806 > 4.605$. Reject null hypothesis at given significance level. Conclude that there is no effect.

c. What is the smallest sample size *n* for which these observed proportions would result in rejection of the independence hypothesis?

$$\frac{4.605}{0.006806} = 676.61 \rightarrow 677$$