Chapter 13 – Probability Rules!

Section 13.1

1. Pet ownership.

$$P(\text{dog or cat}) = P(\text{dog}) + P(\text{cat}) - P(\text{dog and cat}) = 0.25 + 0.29 - 0.12 = 0.42$$

2. Cooking and shopping.

$$\begin{aligned}P(\text{likes to cook or likes to shop}) &= P(\text{likes to cook}) + P(\text{likes to shop}) - P(\text{likes to cook and likes to shop})\\ &= 0.45 + 0.59 - 0.23 = 0.81\end{aligned}$$

Section 13.2

3. Sports.

	Football	No Football	Total
Basketball	27	13	40
No Basketball	38	22	60
Total	65	35	100

$P(\text{football} \mid \text{basketball}) = \dfrac{P(\text{football and basketball})}{P(\text{basketball})} = \dfrac{\frac{27}{100}}{\frac{40}{100}} = 0.675$; (Or, use the table. Of the 40 people who like to watch basketball, 27 people also like to watch football. 27/40 = 0.675)

4. Sports again.

$P(\text{football} \mid \text{no basketball}) = \dfrac{P(\text{football and no basketball})}{P(\text{no basketball})} = \dfrac{\frac{38}{100}}{\frac{60}{100}} \approx 0.633$; (Or, use the table. Of the 60 people who don't like to watch basketball, 38 people like to watch football. 38/60 ≈ 0.633)

5. Late to the train.

$$P(\text{let out late and missing train}) = P(\text{let out late}) \times P(\text{missing train} \mid \text{let out late}) = (0.30)(0.45) = 0.135$$

6. Field goals.

$$P(\text{make first and make second}) = P(\text{make first}) \times P(\text{make second} \mid \text{make first}) = (0.70)(0.90) = 0.63$$

Section 13.3

7. Titanic.

The overall survival rate, $P(S)$, was 0.323, yet the survival rate for first-class passengers, $P(S \mid FC)$, was 0.625. Since, $P(S) \neq P(S \mid FC)$, survival and ticket class are not independent. Rather, survival rate depended on class.

8. Births.

If sex of a child is independent of gender, then $P(\text{girl} \mid \text{four boys}) = P(\text{girl})$. This means that the probability of a woman giving birth to a girl after having four boys is not greater than it was at her first birth. These probabilities are the same.

Section 13.4

9. Facebook.

	U.S.	Not U.S.	Total
Log on Every Day	0.20	0.30	0.50
Do Not Log on Every Day	0.10	0.40	0.50
Total	0.30	0.70	1.00

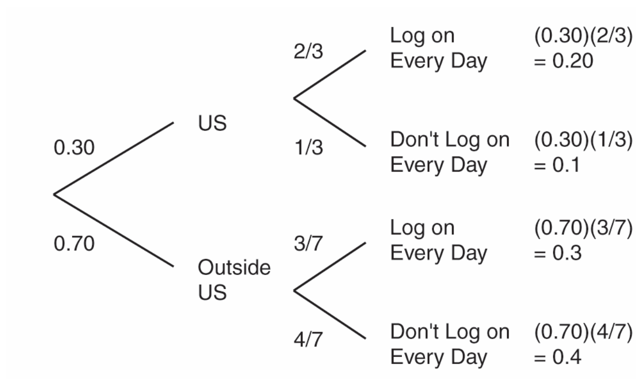
We have joint probabilities and marginal probabilities, not conditional probabilities, so a table is the better choice.

10. Online banking.

	Bank Online	Don't Bank Online	Total
Under 50	0.25	0.15	0.40
50 or older	0.05	0.55	0.60
Total	0.30	0.70	1.00

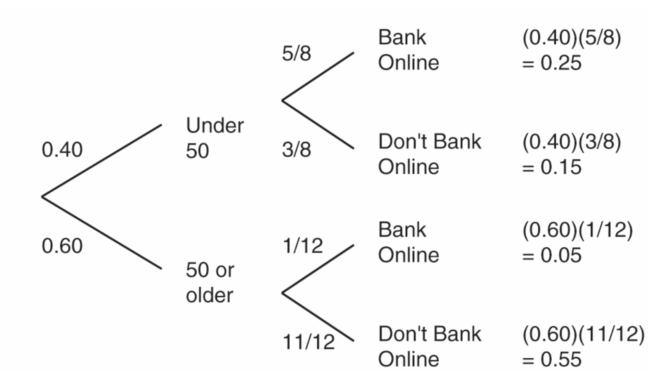
We have joint probabilities and marginal probabilities, not conditional probabilities, so a table is the better choice.

11. Facebook again.



A tree is better because we have conditional and marginal probabilities. The joint probabilities are found at the end of the branches.

12. Online banking again.



A tree is better because we have conditional and marginal probabilities. The joint probabilities are found at the end of the branches.

Section 13.5

13. Facebook final.

$$P(\text{US} \mid \text{Log on every day}) = \frac{P(\text{US and Log on every day})}{P(\text{Log on every day})} = \frac{0.20}{0.20+0.30} = 0.40$$

Knowing that a person logs on every day increases probability that the person is from the United States.

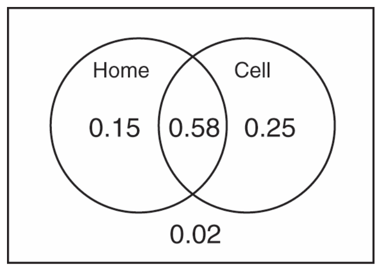
14. Online banking last time.

$$P(\text{Under 50} \mid \text{Bank online}) = \frac{P(\text{Under 50 and Bank online})}{P(\text{Bank online})} = \frac{0.25}{0.25+0.05} \approx 0.833$$

Knowing that someone banks online more than doubles the probability that the person is younger than 50.

Chapter Exercises.

15. Phones.



a) $P(\text{home phone or cell phone}) = P(\text{home}) + P(\text{cell}) - P(\text{home and cell}) = 0.73 + 0.83 - 0.58 = 0.98$

Or, from the Venn: 0.15 + 0.58 + 0.25 = 0.98

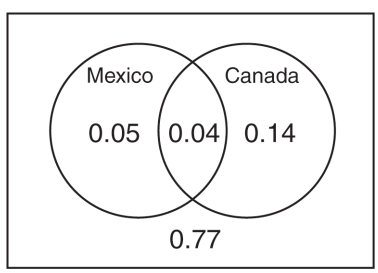
b) $P(\text{neither}) = 1 - P(\text{home phone or cell phone}) = 1 - 0.98 = 0.02$

Or, from the Venn: 0.02 (the region outside the circles)

c) $P(\text{cell but no home}) = P(\text{cell}) - P(\text{home and cell}) = 0.83 - 0.58 = 0.25$

Or, from the Venn: 0.25 (the region inside cell circle, yet outside home circle)

16. Travel.



a) $P(\text{Canada and not Mexico}) = P(\text{Canada}) - P(\text{Canada and Mexico}) = 0.18 - 0.04 = 0.14$

Or, from the Venn: 0.14 (region inside the Canada circle, yet outside the Mexico circle)

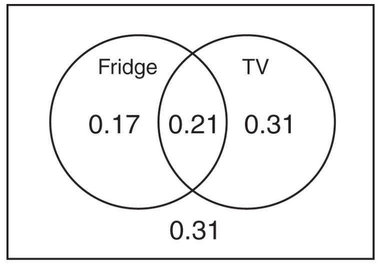
b) $P(\text{either Canada or Mexico}) = P(\text{Canada}) + P(\text{Mexico}) - P(\text{Canada and Mexico})$
$= 0.18 + 0.09 - 0.04 = 0.23$

Or, from the Venn: 0.05 + 0.04 + 0.14 = 0.23 (the regions inside the circles)

c) $P(\text{neither Canada nor Mexico}) = 1 - P(\text{either Canada or Mexico}) = 1 - 0.23 = 0.77$

Or, from the Venn: 0.77 (the region outside the circles)

17. Amenities.



a) P(TV and no refrigerator) = P(TV) – P(TV and refrigerator) = 0.52 – 0.21 = 0.31

Or, from the Venn: 0.31 (inside the TV circle, yet outside the refrigerator circle)

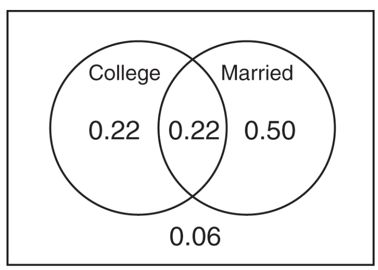
b) P(refrigerator or TV, but not both)
$= [P(\text{refrigerator}) - P(\text{refrigerator and TV})] + [P(\text{TV}) - P(\text{refrigerator and } TV)]$
$= [0.38 - 0.21] + [0.52 - 0.21] = 0.48$

Using the Venn diagram, simply add the probabilities in the two regions for Fridge only and TV only. P(refrigerator or TV, but not both) = 0.17 + 0.31 = 0.48

c) P(neither TV nor refrigerator) $= 1 - P$(either TV or refrigerator)
$= 1 - [P(\text{TV}) + P(\text{refrigerator}) - P(\text{TV and refrigerator})]$
$= 1 - [0.52 + 0.38 - 0.21]$
$= 0.31$

Or, from the Venn: 0.31 (the region outside the circles)

18. Workers.



a) P(neither married nor a college graduate) $= 1 - P$(either married or college graduate)
$= 1 - [P(\text{married}) + P(\text{college graduate}) - P(\text{both})]$
$= 1 - [0.72 + 0.44 - 0.22]$
$= 1 - [0.94]$
$= 0.06$

Or, from the Venn: 0.06 (outside the circles)

b) P(married and not a college graduate) = $P(\text{married}) - P(\text{married and a college graduate})$
$= 0.72 - 0.22$
$= 0.50$

Or, from the Venn: 0.50 (inside the Married circle, yet outside the College circle)

c) P(married or a college graduate) = $P(\text{married}) + P(\text{college graduate}) - P(\text{both})$
$= 0.72 + 0.44 - 0.22$
$= 0.94$

Or, from the Venn diagram: 0.22 + 0.22 + 0.50 = 0.94 (inside the circles)

19. Global survey.

a) $P(\text{USA}) = \dfrac{1557}{7690} \approx 0.2025$

b) $P(\text{some high school or primary or less}) = \dfrac{4195}{7690} + \dfrac{1161}{7690} \approx 0.6965$; If it is assumed that those that did not answer did not complete college, $P(\text{some high school or primary or less}) = \dfrac{4195}{7690} + \dfrac{1161}{7690} + \dfrac{45}{7690} \approx 0.7023.$

c)
$$\begin{aligned} P(\text{France or post-graduate}) &= P(\text{France}) + P(\text{post-graduate}) - P(\text{both}) \\ &= \frac{1539}{7690} + \frac{379}{7690} - \frac{69}{7690} \approx 0.2404 \end{aligned}$$

d) $P(\text{France and primary school or less}) = \dfrac{309}{7690} \approx 0.0402$

20. Birth order.

a) $P(\text{Human Ecology}) = \dfrac{43}{223} \approx 0.193$

b) $P(\text{first-born}) = \dfrac{113}{223} \approx 0.507$

c) $P(\text{first-born and Human Ecology}) = \dfrac{15}{223} \approx 0.067$

d)
$$\begin{aligned} P(\text{first-born or Human Ecology}) &= P(\text{first-born}) + P(\text{Human Ecology}) - P(\text{first-born and Human Ecology}) \\ &= \frac{113}{223} + \frac{43}{223} - \frac{15}{223} \approx 0.632 \end{aligned}$$

21. Cards.

a) $P(\text{heart} \mid \text{red}) = \dfrac{P(\text{heart and red})}{P(\text{red})} = \dfrac{13/52}{26/52} = \dfrac{1}{2} = 0.50$; A more intuitive approach is to think about only the red cards. Half of them are hearts.

b) $P(\text{red} \mid \text{heart}) = \dfrac{P(\text{red and heart})}{P(\text{heart})} = \dfrac{13/52}{13/52} = 1$; Think about only the hearts. They are all red!

c) $P(\text{ace} \mid \text{red}) = \dfrac{P(\text{ace and red})}{P(\text{red})} = \dfrac{2/52}{26/52} = \dfrac{2}{26} \approx 0.077$; Consider only the red cards. Of those 26 cards, 2 of them are aces.

d) $P(\text{queen} \mid \text{face}) = \dfrac{P(\text{queen and face})}{P(\text{face})} = \dfrac{4/52}{12/52} \approx 0.333$; There are 12 faces cards: 4 jacks, 4 queens, and 4 kings. Four of the 12 face cards are queens.

22. Pets.

Organize the counts in a two-way table.

	Cats	Dogs	Total
Male	6	8	14
Female	12	16	28
Total	18	24	42

a) $P(\text{male} \mid \text{cat}) = \dfrac{P(\text{male and cat})}{P(\text{cat})} = \dfrac{6/42}{18/42} = \dfrac{6}{18} \approx 0.333$; Consider only the Cats column. There are 6 male cats, out of a total of 18 cats.

b) $P(\text{cat} \mid \text{female}) = \dfrac{P(\text{cat and female})}{P(\text{female})} = \dfrac{12/42}{28/42} = \dfrac{12}{28} \approx 0.429$; We are interested in the Female row. Of the 28 female animals, 12 are cats.

c) $P(\text{female} \mid \text{dog}) = \dfrac{P(\text{female and dog})}{P(\text{dog})} = \dfrac{16/42}{24/42} = \dfrac{16}{24} \approx 0.667$; Look at only the Dogs column. There are 24 dogs, and 16 of them are female.

23. Health.

Construct a two-way table of the conditional probabilities, including the marginal probabilities.

Cholesterol	Blood Pressure: High	OK	Total
High	0.11	0.21	0.32
OK	0.16	0.52	0.68
Total	0.27	0.73	1.00

a) $P(\text{both conditions}) = 0.11$

b) $P(\text{high BP}) = 0.11 + 0.16 = 0.27$

c) $P(\text{high chol.} \mid \text{high BP}) = \dfrac{P(\text{high chol. and high BP})}{P(\text{high BP})} = \dfrac{0.11}{0.27} \approx 0.407$; Consider only the High Blood Pressure column. Within this column, the probability of having high cholesterol is 0.11 out of a total of 0.27.

d) $P(\text{high BP} \mid \text{high chol.}) = \dfrac{P(\text{high BP and high chol.})}{P(\text{high chol.})} = \dfrac{0.11}{0.32} \approx 0.344$; This time, consider only the high cholesterol row. Within this row, the probability of having high blood pressure is 0.11, out of a total of 0.32.

24. Immigration.

a) Construct a two-way table of the conditional probabilities, including the marginal probabilities.

Stronger Immigration Enforcement

Party		Favor	Oppose	No Opinion	Total
	Republican	0.30	0.04	0.03	0.37
	Democrat	0.22	0.11	0.02	0.35
	Other	0.16	0.07	0.05	0.28
	Total	0.68	0.22	0.10	1.00

i) $P(\text{favor stronger immigration enforcement}) = 0.30 + 0.22 + 0.16 = 0.68$

ii) $P(\text{favor enforcement} \mid \text{Rep.}) = \dfrac{P(\text{favor enforcement and Rep.})}{P(\text{Republican})} = \dfrac{0.30}{0.37} \approx 0.811$; Consider only the Republican row. The probability of favoring stronger immigration enforcement is 0.30 out of a total of 0.37 for that row.

iii) $P(\text{Dem} \mid \text{favor enf.}) = \dfrac{P(\text{Dem and favor enf.})}{P(\text{favor enforcement})} = \dfrac{0.22}{0.68} \approx 0.324$; Consider only the Favor column. The probability of being a Democrat is 0.22 out of a total of 0.68 for that column.

b) $P(\text{Rep. or favor enforcement}) = P(\text{Rep.}) + P(\text{favor enforcement}) - P(\text{both}) = 0.37 + 0.68 - 0.30 = 0.75$; The overall probabilities of being a Republican and of favoring enforcement are from the marginal distribution of probability (the totals). The candidate can expect 75% of the votes, provided her estimates are correct.

25. Global survey, take 2.

a) $P(\text{USA and post-graduate work}) = \dfrac{84}{7690} \approx 0.011$

b) $P(\text{USA} \mid \text{post-graduate}) = \dfrac{84}{379} \approx 0.222$

c) $P(\text{post-graduate} \mid \text{USA}) = \dfrac{84}{1557} \approx 0.054$

d) $P(\text{primary} \mid \text{China}) = \dfrac{506}{1502} \approx 0.337$

e) $P(\text{China} \mid \text{primary}) = \dfrac{506}{1161} \approx 0.436$

26. Birth order, take 2.

a) $P(\text{Arts and Science and second child}) = \dfrac{23}{223} \approx 0.103$

b) $P(\text{second child} \mid \text{Arts and Science}) = \dfrac{23}{57} \approx 0.404$

c) $P(\text{Arts and Science} \mid \text{second child}) = \dfrac{23}{110} \approx 0.209$

d) $P(\text{Agriculture} \mid \text{first-born}) = \dfrac{52}{113} \approx 0.460$

e) $P(\text{first-born} \mid \text{Agriculture}) = \dfrac{52}{93} \approx 0.559$

27. Sick kids.

Having a fever and having a sore throat are not independent events.
P(fever and sore throat)= P(Fever) P(Sore Throat | Fever) = (0.70)(0.30) = 0.21; The probability that a kid with a fever has a sore throat is 0.21.

28. Sick cars.

Needing repairs and paying more than $400 for the repairs are not independent events. (What happens to the probability of paying more than $400, if you don't need repairs?)

$$\begin{aligned} &P(\text{needing repairs and paying more than } \$400) \\ &\quad = P(\text{needing repairs})P(\text{paying more than } \$400 \mid \text{repairs are needed}) \\ &\quad = (0.20)(0.40) = 0.08 \end{aligned}$$

29. Cards.

a) $P(\text{first heart drawn is on the third card}) = P(\text{no heart})P(\text{no heart})P(\text{heart}) = \left(\frac{39}{52}\right)\left(\frac{38}{51}\right)\left(\frac{13}{50}\right) \approx 0.145$

b) $P(\text{all three cards drawn are red}) = P(\text{red})P(\text{red})P(\text{red}) = \left(\frac{26}{52}\right)\left(\frac{25}{51}\right)\left(\frac{24}{50}\right) \approx 0.118$

c) $P(\text{none of the cards are spades}) = P(\text{no spade})P(\text{no spade})P(\text{no spade}) = \left(\frac{39}{52}\right)\left(\frac{38}{51}\right)\left(\frac{37}{50}\right) \approx 0.414$

d)
$$\begin{aligned} P(\text{at least one of the cards is an ace}) &= 1 - P(\text{none of the cards are aces}) \\ &= 1 - \left[P(\text{no ace})P(\text{no ace})P(\text{no ace})\right] \\ &= 1 - \left(\frac{48}{52}\right)\left(\frac{47}{51}\right)\left(\frac{46}{50}\right) \approx 0.217 \end{aligned}$$

30. Another hand.

a) $P(\text{none of the cards are aces}) = P(\text{no ace})P(\text{no ace})P(\text{no ace}) = \left(\frac{48}{52}\right)\left(\frac{47}{51}\right)\left(\frac{46}{50}\right) \approx 0.783$

b) $P(\text{all of the cards are hearts}) = P(\text{heart})P(\text{heart})P(\text{heart}) = \left(\frac{13}{52}\right)\left(\frac{12}{51}\right)\left(\frac{11}{50}\right) \approx 0.013$

c) $P(\text{the third card is the first red}) = P(\text{no red})P(\text{no red})P(\text{red}) = \left(\frac{26}{52}\right)\left(\frac{25}{51}\right)\left(\frac{26}{50}\right) \approx 0.127$

d)
$$\begin{aligned} P(\text{at least one card is a diamond}) &= 1 - P(\text{no cards are diamonds}) \\ &= 1 - \left[P(\text{no diam.})P(\text{no diam.})P(\text{no diam.})\right] \\ &= 1 - \left(\frac{39}{52}\right)\left(\frac{38}{51}\right)\left(\frac{37}{50}\right) \approx 0.586 \end{aligned}$$

31. Batteries.

Since batteries are not being replaced, use conditional probabilities throughout.

a) $P(\text{the first two batteries are good}) = P(\text{good})P(\text{good}) = \left(\frac{7}{12}\right)\left(\frac{6}{11}\right) \approx 0.318$

b) $$\begin{aligned} P(\text{at least one of the first three batteries works}) &= 1 - P(\text{none of the first three batteries work}) \\ &= 1 - \left[P(\text{no good})P(\text{no good})P(\text{no good})\right] \\ &= 1 - \left(\frac{5}{12}\right)\left(\frac{4}{11}\right)\left(\frac{3}{10}\right) \approx 0.955 \end{aligned}$$

c) $P(\text{the first four batteries are good}) = P(\text{good})P(\text{good})P(\text{good})P(\text{good}) = \left(\frac{7}{12}\right)\left(\frac{6}{11}\right)\left(\frac{5}{10}\right)\left(\frac{4}{9}\right) \approx 0.071$

d) $$\begin{aligned} P(\text{pick five to find one good}) &= P(\text{not good})P(\text{not good})P(\text{not good})P(\text{not good})P(\text{good}) \\ &= \left(\frac{5}{12}\right)\left(\frac{4}{11}\right)\left(\frac{3}{10}\right)\left(\frac{2}{9}\right)\left(\frac{7}{8}\right) \approx 0.009 \end{aligned}$$

32. Shirts.

You need two shirts so don't replace them. Use conditional probabilities throughout.

a) $$\begin{aligned} P(\text{the first two are not mediums}) &= P(\text{not medium})\ P(\text{not medium}) \\ &= \left(\frac{16}{20}\right)\left(\frac{15}{19}\right) \approx 0.632 \end{aligned}$$

b) $$\begin{aligned} P(\text{the first medium is the third shirt}) &= P(\text{not medium})\ P(\text{not medium})\ P(\text{medium}) \\ &= \left(\frac{16}{20}\right)\left(\frac{15}{19}\right)\left(\frac{4}{18}\right) \approx 0.140 \end{aligned}$$

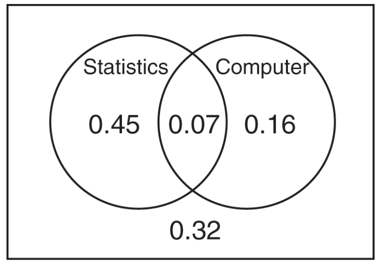
c) $$\begin{aligned} P(\text{the first four shirts are extra-large}) &= P(\text{XL})\ P(\text{XL})\ P(\text{XL})\ P(\text{XL}) \\ &= \left(\frac{6}{20}\right)\left(\frac{5}{19}\right)\left(\frac{4}{18}\right)\left(\frac{3}{17}\right) \approx 0.003 \end{aligned}$$

d) $$\begin{aligned} P(\text{at least one of four is a medium}) &= 1 - P(\text{none of the first four shirts are mediums}) \\ &= 1 - \left[P(\text{not med.})\ P(\text{not med.})\ P(\text{not med.})\ P(\text{not med.})\right] \\ &= 1 - \left(\frac{16}{20}\right)\left(\frac{15}{19}\right)\left(\frac{14}{18}\right)\left(\frac{13}{17}\right) \approx 0.624 \end{aligned}$$

33. Eligibility.

a) $P(\text{eligible}) = P(\text{stats}) + P(\text{computer}) - P(\text{both}) = 0.52 + 0.23 - 0.07 = 0.68$; 68% of students are eligible for BioResearch, so 100 – 68 = 32% are ineligible.

From the Venn, the region outside the circles represents those students who have taken neither course, and are therefore ineligible for BioResearch.



b) $$P(\text{computer course} \mid \text{statistics}) = \frac{P(\text{computer and statistics})}{P(\text{statistics})} = \frac{0.07}{0.52} \approx 0.135$$

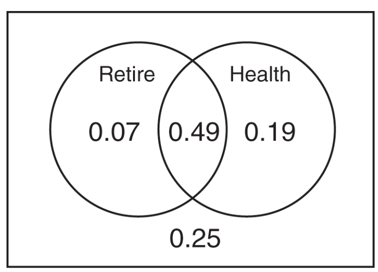
From the Venn, consider only the region inside the Statistics circle. The probability of having taken a computer course is 0.07 out of a total of 0.52 (the entire Statistics circle).

c) Taking the two courses are not disjoint events, since they have outcomes in common. In fact, 7% of juniors have taken both courses.

d) Taking the two courses are not independent events. The overall probability that a junior has taken a computer course is 0.23. The probability that a junior has taken a computer course given that he or she has taken a statistics course is 0.135. If taking the two courses were independent events, these probabilities would be the same.

34. Benefits.

Construct a Venn diagram of the possible outcomes.



a) $$\begin{aligned} P(\text{neither benefit}) &= 1 - P(\text{either retirement or health}) \\ &= 1 - [P(\text{retirement}) + P(\text{health}) - P(\text{both})] \\ &= 1 - [0.56 + 0.68 - 0.49] = 0.25 \end{aligned}$$

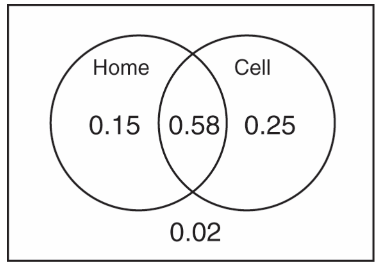
b) $P(\text{health ins.} \mid \text{retirement}) = \dfrac{P(\text{health insurance and retirement})}{P(\text{retirement})} = \dfrac{0.49}{0.56} = 0.875$; From the Venn, consider only the region inside the Retirement circle. The probability that a worker has health insurance is 0.49 out of a total of 0.56 (the entire Retirement circle).

c) Having health insurance and a retirement plan are not independent events. Sixty-eight percent of all workers have health insurance, while 87.5% of workers with retirement plans also have health insurance. If having health insurance and a retirement plan were independent events, these percentages would be the same.

d) Having these two benefits are not disjoint events, since they have outcomes in common. Forty-nine percent of workers have both health insurance and a retirement plan.

35. Cell phones in the home.

Construct a Venn diagram of the possible outcomes.



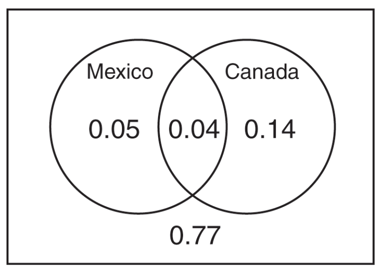
a) $P(\text{cell} \mid \text{home}) = \dfrac{P(\text{cell and home})}{P(\text{home})} = \dfrac{0.58}{0.73} \approx 0.795$; From the Venn, consider only the region inside the Home circle. The probability that the person has a cell phone is 0.58 out of 0.73 (the entire Home circle).

b) Having a home phone and a cell phone are not independent events. Seventy-nine and a half percent of people with home phones have cell phones. Overall, 83% of people have cell phones. If having a home phone and cell phone were independent events, these would be the same.

c) No, having a home phone and cell phone are not disjoint events. Fifty-eight percent of people have both.

36. On the road again.

Construct a Venn diagram of the possible outcomes.



a) $P(\text{Canada} \mid \text{Mexico}) = \dfrac{P(\text{Canada and Mexico})}{P(\text{Mexico})} = \dfrac{0.04}{0.09} \approx 0.444$

From the Venn, consider only the region inside the Mexico circle. The probability that an American has traveled to Canada is 0.04 out of a total of 0.09 (the entire Mexico circle).

b) No, travel to Mexico and Canada are not disjoint events. Four percent of Americans have been to both countries.

c) No, travel to Mexico and Canada are not independent events. Eighteen percent of U.S. residents have been to Canada. Forty-four point four percent% of the U.S. residents who have been to Mexico have also been to Canada. If travel to the two countries were independent, the percentages would be the same.

37. Cards.

Yes, getting an ace is independent of the suit when drawing one card from a well shuffled deck. The overall probability of getting an ace is 4/52, or 1/13, since there are 4 aces in the deck. If you consider just one suit, there is only 1 ace out of 13 cards, so the probability of getting an ace given that the card is a diamond, for instance, is 1/13. Since the probabilities are the same, getting an ace is independent of the suit.

38. Pets, again.

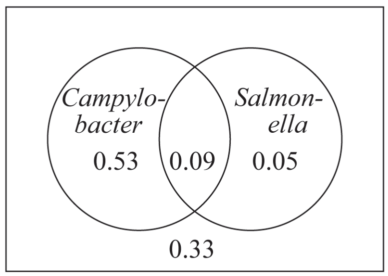
Consider the two-way table from Exercise 22.

	Cats	Dogs	Total
Male	6	8	14
Female	12	16	28
Total	18	24	42

Yes, species and gender are independent events. 8 of 24, or 1/3 of the dogs are male, and 6 of 18, or 1/3 of the cats are male. Since these are the same, species and gender are independent events.

39. Unsafe food.

a) Using the Venn diagram, the probability that a tested chicken was not contaminated with either kind of bacteria is 33%.



b) Contamination with *campylobacter* and contamination with *salmonella* are not disjoint events, since 9% of chicken is contaminated with both.

c) Contamination with *campylobacter* and contamination with *salmonella* may be independent events. The probability that a tested chicken is contaminated with *campylobacter* is 0.62. The probability that chicken contaminated with *salmonella* is also contaminated with *campylobacter* is $0.09/0.14 \approx 0.64$. If chicken is contaminated with *salmonella*, it is only slightly more likely to be contaminated with *campylobacter* than chicken in general. This difference could be attributed to expected variation due to sampling.

40. Birth order, finis.

a) Yes, since the events share no outcomes. Students can enroll in only one college.

b) No, since knowing that one event is true drastically changes the probability of the other. The probability of a student being in the Agriculture college is nearly 42%. The probability of a student being in the Human Ecology college, given that he or she is in the Agriculture college is 0.

c) No, since they share outcomes. Fifteen students were first-born, Human Ecology students.

d) No, since knowing that one event is true drastically changes the probability of the other. Over 19% of all students enrolled in Human Ecology, but only 13% of first-borns did.

41. Men's health, again.

Consider the two-way table from Exercise 23.

		Blood Pressure		
		High	OK	Total
Cholesterol	High	0.11	0.21	0.32
	OK	0.16	0.52	0.68
	Total	0.27	0.73	1.00

High blood pressure and high cholesterol are not independent events. Twenty-eight point eight percent of men with OK blood pressure have high cholesterol, while 40.7% of men with high blood pressure have high cholesterol. If having high blood pressure and high cholesterol were independent, these percentages would be the same.

42. Politics.

Consider the two-way table from Exercise 24.

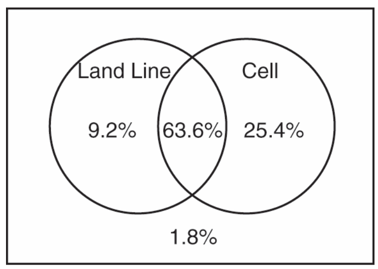
Stronger Immigration Enforcement

Party		Favor	Oppose	No Opinion	Total
	Republican	0.30	0.04	0.03	0.37
	Democrat	0.22	0.11	0.02	0.35
	Other	0.16	0.07	0.05	0.28
	Total	0.68	0.22	0.10	1.00

Party affiliation and position on the immigration are not independent events. Eighty-one point zero eight percent of Republicans favor stronger immigration enforcement, but only 62.85% of Democrats favor it. If the events were independent, then these percentages would be the same.

43. Phone service.

Organize the percentages in a Venn diagram.

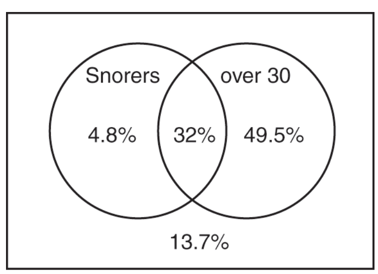


a) Since 25.4% of U.S. adults have only a cell phone, and 1.8% have no phone at all, polling organizations can reach 100 – 25.4 – 1.8 = 72.8% of U.S. adults.

b) Using the Venn diagram, about 72.8% of U.S. adults have a land line. The probability of a U.S. adults having a land line given that they have a cell phone is 63.6/(63.6 + 25.4) or about 71.5%. It appears that having a cell phone and having a land line are independent, since the probabilities are roughly the same.

44. Snoring.

Organize the percentages in a Venn diagram.



a) Thirteen point seven percent of the respondents were under 30 and did not snore.

b) According to this survey, snoring is not independent of age. Thirty-six point eight percent of the 995 adults snored, but 32/(32 + 49.5) ≈ 39.3% of those over 30 snored.

45. Gender.

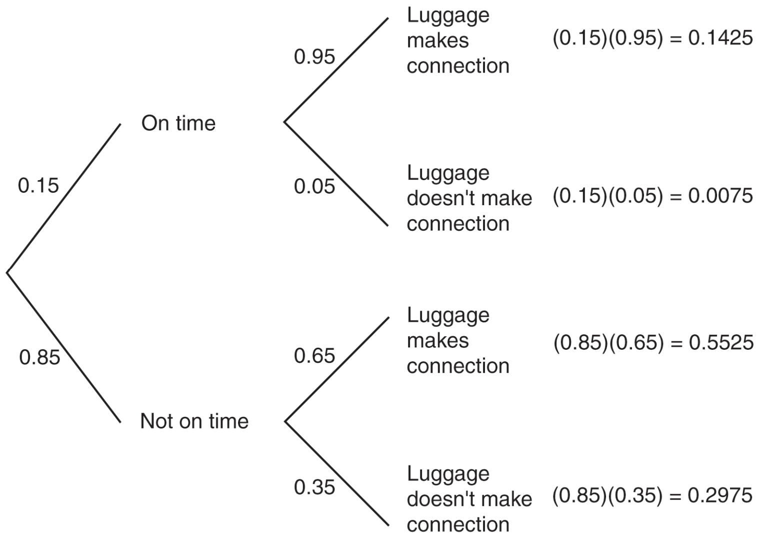
According to the poll, party affiliation is not independent of sex. Overall, (32+41)/186 ≈ 39.25% of the respondents were Democrats. Of the men, only 32/94 ≈ 34.04% were Democrats.

46. Cars.

According to the survey, country of origin of the car is not independent of type of driver. (33+12)/359 ≈ 12.5% of the cars were of European origin, but about 33/195 ≈ 16.9% of the students drive European cars.

47. Luggage.

Organize using a tree diagram.

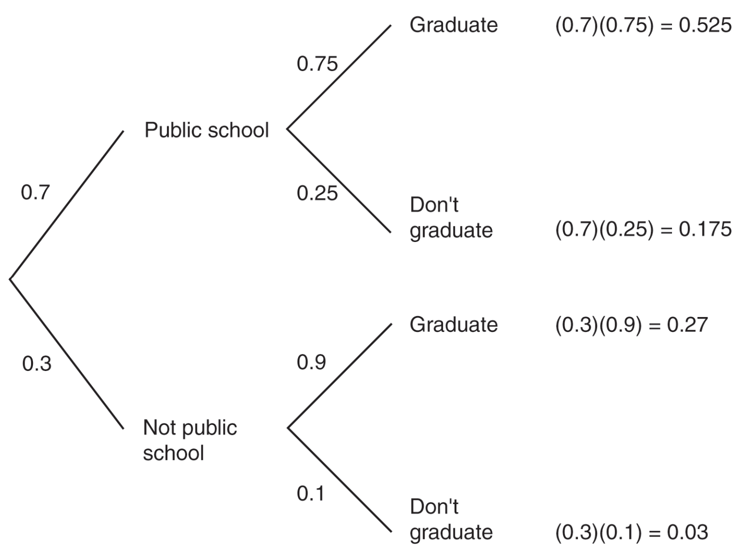


a) No, the flight leaving on time and the luggage making the connection are not independent events. The probability that the luggage makes the connection is dependent on whether or not the flight is on time. The probability is 0.95 if the flight is on time, and only 0.65 if it is not on time.

b)
$$\begin{aligned} P(\text{Luggage}) &= P(\text{On time and Luggage}) + P(\text{Not on time and Luggage}) \\ &= (0.15)(0.95) + (0.85)(0.65) \\ &= 0.695 \end{aligned}$$

48. Graduation.

a) Yes, there is evidence to suggest that a freshman's chances to graduate depend upon what kind of high school the student attended. The graduation rate for public school students is 75%, while the graduation rate for others is 90%. If the high school attended was independent of college graduation, these percentages would be the same.



48. (continued)

b) $P(\text{Graduate}) = P(\text{Public and Graduate}) + P(\text{Not public and Graduate}) = (0.7)(0.75) + (0.3)(0.9) = 0.795$; Overall, 79.5% of freshmen are expected to eventually graduate.

49. Late luggage.

Refer to the tree diagram constructed for Exercise 47.

$$P(\text{Not on time} \mid \text{No Lug.}) = \frac{P(\text{Not on time and No Luggage})}{P(\text{No Luggage})} = \frac{(0.85)(0.35)}{(0.15)(0.05)+(0.85)(0.35)} \approx 0.975$$

If you pick Leah up at the Denver airport and her luggage is not there, the probability that her first flight was delayed is 0.975.

50. Graduation, part II.

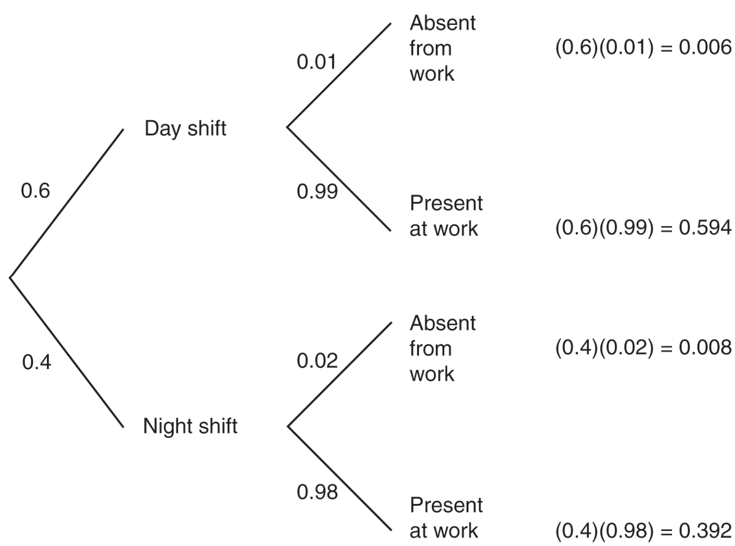
Refer to the tree diagram constructed for Exercise 48.

$$P(\text{Public} \mid \text{Graduate}) = \frac{P(\text{Public and Graduate})}{P(\text{Graduate})} = \frac{(0.7)(0.75)}{(0.7)(0.75)+(0.3)(0.9)} \approx 0.660$$

Overall, 66.0% of the graduates of the private college went to public high schools.

51. Absenteeism.

Organize the information in a tree diagram.



a) No, absenteeism is not independent of shift worked. The rate of absenteeism for the night shift is 2%, while the rate for the day shift is only 1%. If the two were independent, the percentages would be the same.

b) $P(\text{Absent}) = P(\text{Day and Absent}) + P(\text{Night and Absent}) = (0.6)(0.01) + (0.4)(0.02) = 0.014$; The overall rate of absenteeism at this company is 1.4%.

52. E-readers.

a) Owning an e-reader and reading at least one book are not independent, since the percentage of people who have read at least one book are different for owners of e-readers and U.S. adults overall. Eighty-seven point five percent of owners of e-readers (0.28/0.32) have read at least one book in the previous year, while only 76% of all U.S. adults have read at least one book in the previous year.

b) If 28% of U.S. adults have read at least one e-book, and 32% have e-readers, then 32% – 28% = 4% of e-reader owners have not read at least one book in the previous year.

53. Absenteeism, part II.

Refer to the tree diagram constructed for Exercise 51.

$$P(\text{Night} \mid \text{Absent}) = \frac{P(\text{Night and Absent})}{P(\text{Absent})} = \frac{(0.4)(0.02)}{(0.6)(0.01)+(0.4)(0.02)} \approx 0.571$$

Approximately 57.1% of the company's absenteeism occurs on the night shift.

54. E-readers II.

a) $P(\text{hasn't read at least 1 book} \mid \text{e-reader}) = \frac{P(\text{ hasn't read at least 1 book and e-reader})}{P(\text{e-reader})} = \frac{0.04}{0.32} = 0.125$

The probability that a randomly selected U.S. adult has read at least one book given that he or she has an e-reader is 12.5%.

b) We know that 24% of U.S. adults have not read any type of book in the previous year, and 4% of U.S. adults were e-reader owners who have not read a book in the previous year. This means that 24% – 4% = 20% of U.S. adults have no e-reader and have read no books.

$$P(\text{hasn't read at least 1 book} \mid \text{no e-reader}) = \frac{P(\text{ hasn't read at least 1 book and no e-reader})}{P(\text{no e-reader})} = \frac{0.20}{0.68} \approx 0.294$$

It is more likely that a U.S. adult who does not own an e-reader would have read no books in the previous year.

55. Drunks.

Organize the information into a tree diagram.

a) $P(\text{Detain} \mid \text{Not Drinking}) = 0.20$

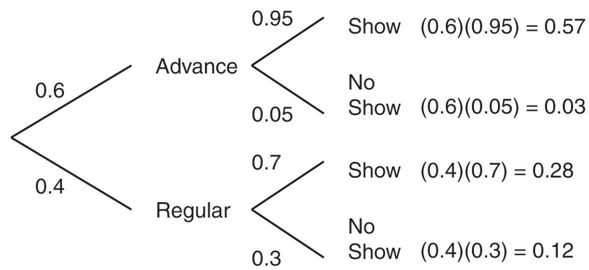
b) $P(\text{Detain}) = P(\text{Drinking and Det.}) + (\text{Not Drinking and Det.}) = (0.12)(0.8)+(0.88)(0.2) = 0.272$

c) $P(\text{Drunk} \mid \text{Det.}) = \frac{P(\text{Drunk and Det.})}{P(\text{Detain})} = \frac{(0.12)(0.8)}{(0.12)(0.8)+(0.88)(0.2)} \approx 0.353$

d) $P(\text{Drunk} \mid \text{Release}) = \frac{P(\text{Drunk and Release})}{P(\text{Release})} = \frac{(0.12)(0.2)}{(0.12)(0.2)+(0.88)(0.8)} \approx 0.033$

56. No-shows.

Organize the information into a tree diagram.



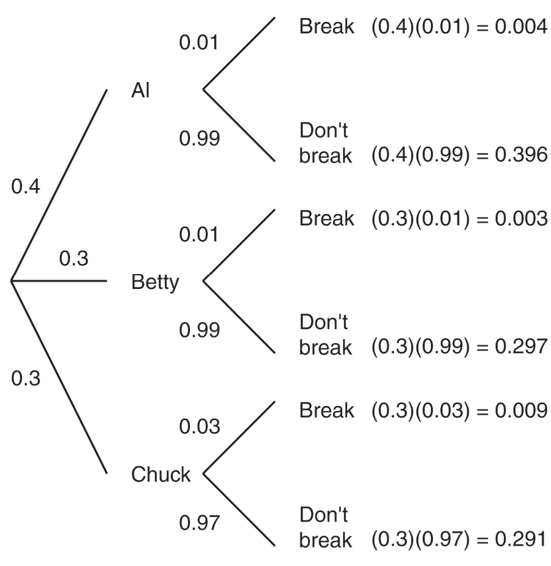
a)
$$\begin{aligned} P(\text{No Show}) &= P(\text{Advance and No Show}) + P(\text{Regular and No Show}) \\ &= (0.60)(0.05) + (0.40)(0.30) \\ &= 0.03 + 0.12 \\ &= 0.15, \text{ or } 15\% \end{aligned}$$

b)
$$P(\text{Advance} \mid \text{No Show}) = \frac{P(\text{Advance and No Show})}{P(\text{No Show})} = \frac{0.03}{0.15} = 0.20$$

c) No, being a no show is not independent of the type of ticket a passenger holds. While 30% of regular fare passengers are no shows, only 5% of advanced sale fare passengers are no shows.

57. Dishwashers.

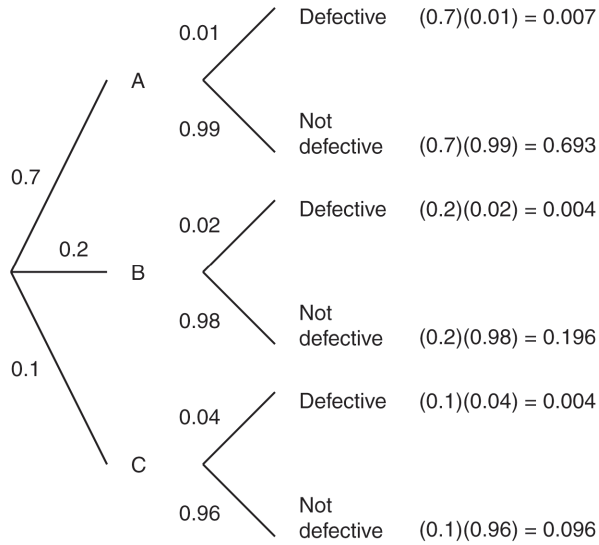
Organize the information in a tree diagram.



$$P(\text{Chuck} \mid \text{Break}) = \frac{P(\text{Chuck and Break})}{P(\text{Break})} = \frac{(0.3)(0.03)}{(0.4)(0.01) + (0.3)(0.01) + (0.3)(0.03)} \approx 0.563;$$ If you hear a dish break, the probability that Chuck is on the job is approximately 0.563.

58. Parts.

Organize the information in a tree diagram.

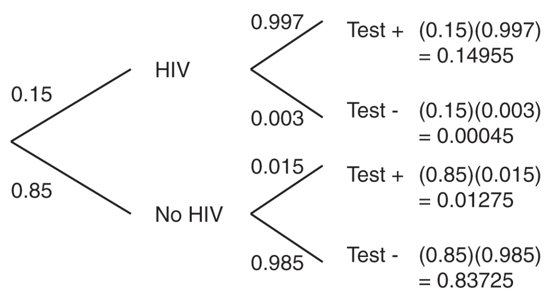


$$P(\text{Supplier A} \mid \text{Defective}) = \frac{P(\text{Supplier A and Defective})}{P(\text{Defective})} = \frac{(0.7)(0.01)}{(0.7)(0.01) + (0.2)(0.02) + (0.1)(0.04)} \approx 0.467$$

The probability that a defective component came from supplier A is approximately 0.467.

59. HIV Testing.

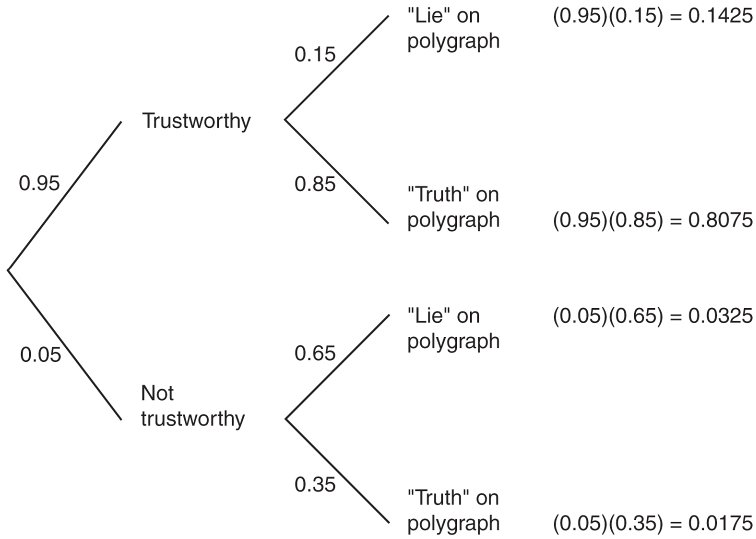
Organize the information in a tree diagram.



$P(\text{No HIV} \mid \text{Test} -) = \dfrac{P(\text{No HIV and Test} -)}{P(\text{Test} -)} = \dfrac{0.83725}{0.00045 + 0.83725} \approx 0.9995$; the probability that a patient testing negative is truly free of HIV is about 99.95%.

60. Polygraphs.

“” Organize the information in a tree diagram.



$$P(\text{Trustworthy} \mid \text{“Lie” on polygraph}) = \frac{P(\text{Trustworthy and “Lie” on polygraph})}{P(\text{“Lie” on polygraph})}$$

$$= \frac{(0.95)(0.15)}{(0.95)(0.15) + (0.05)(0.65)} \approx 0.8143$$

The probability that a job applicant rejected under suspicion of dishonesty is actually trustworthy is about 0.8143.

61.

Answers will vary.