INSTRUCTOR'S SOLUTIONS MANUAL

DISCRETE MATHEMATICS

FIFTH EDITION

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Chapter 1

An Introduction to Combinatorial Problems and Techniques

1.1 THE TIME TO COMPLETE A PROJECT

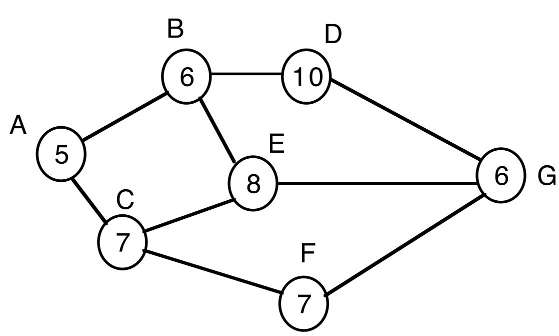
2. 31; A-B-E-G

4. 39; A-C-G-H

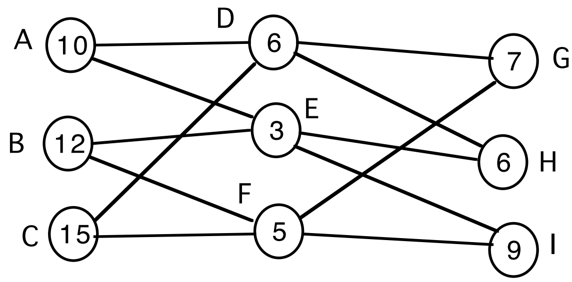
6. 16; B-D-F-H

8. 27; A-D-E-H

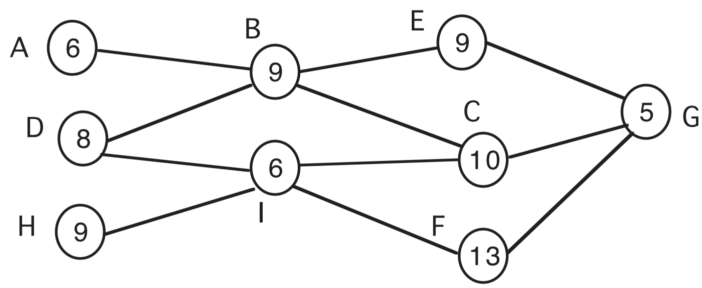
10. 27; A-B-D-G



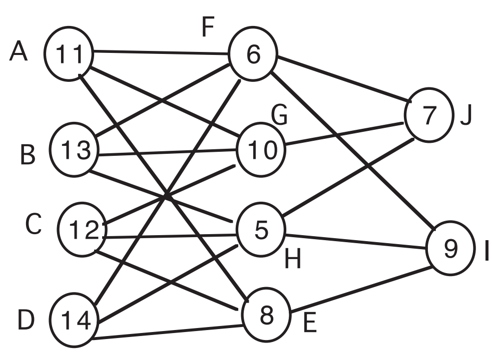
12. 29; C-F-I



14. 33; H-I-F-G



16. 31; D-E-I



18. 20 minutes

1.2 A MATCHING PROBLEM

2. 720 **4.** 210 **6.** 84 **8.** 1680

10. 19,958,400 **12.** $\frac{1}{8}$ **14.** 5040 **16.** 126

18. 210 **20.** 119 **22.** 1320 **24.** 5040

26. 240 **28.** 1200

1.3 A KNAPSACK PROBLEM

2. T **4.** F **6.** F **8.** F

10. T **12.** T **14.** T **16.** no

18. yes; 32

20. $\varnothing$, $\{1\}$, $\{2\}$, $\{3\}$, $\{4\}$, $\{1,2\}$, $\{1,3\}$, $\{1,4\}$, $\{2,3\}$, $\{2,4\}$, $\{3,4\}$, $\{1,2,3\}$, $\{1,2,4\}$, $\{1,3,4\}$, $\{2,3,4\}$, $\{1,2,3,4\}$; 16

22. 128 **24.** 1024 **26.** 256 **28.** 26

30. $\{1,4,6,7,8,9,10,11,12\}$

1.4 ALGORITHMS AND THEIR EFFICIENCY

2. yes; 0 **4.** no

6. no **8.** -1, 9, 84; 3, 17, 84

10. -4, -4, 41, 95; 2, 11, 33, 95 **12.** 111000

14. 001010

16.

k	j	a_1	a_2	a_3
3		1	1	1
2		1	1	1
1		1	1	1
0		1	1	1

18.

k	j	a_1	a_2	a_3	a_4
4		1	1	1	0
		1	1	1	1

20. The circled numbers in the table below indicated the items being compared.

a_1	a_2	a_3	a_4	j	k
23	5	17	12	1	3
23	5	12	17		2
23	5	12	17		1
5	23	12	17	2	3
5	23	12	17		2
5	12	23	17	3	3
5	12	17	23		

22. The circled numbers in the table below indicated the items being compared.

a_1	a_2	a_3	a_4	a_5	j	k
88	2	75	10	48	1	4
88	2	75	10	48		3
88	2	10	75	48		2
88	2	10	75	48		1
2	88	10	75	48	2	4
2	88	10	48	75		3
2	88	10	48	75		2
2	10	88	48	75	3	4
2	10	88	48	75		3
2	10	48	88	75	4	4
2	10	48	75	88		

24. 6.5 years, 2.7 seconds

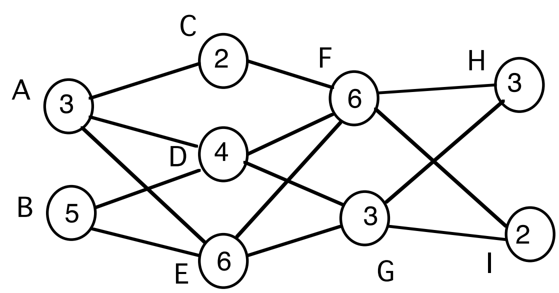
26. 2.3×10^{10} years, 12.5 seconds

28. $4n - 3$ **30.** $3n - 2$

32. -4, -4, 41, 95

SUPPLEMENTARY EXERCISES

2. 20; B-E-F-H



4. 336 **6.** 40 **8.** 14040

10. T **12.** F **14.** T

16. T **18.** 16 **20.** no

22. yes; 0 **24.** -5, 7, 7, 88

26. $\varnothing$, $\{4\}$, $\{3\}$, $\{3,4\}$, $\{2\}$, $\{2,4\}$, $\{2,3\}$, $\{2,3,4\}$, $\{1\}$, $\{1,4\}$, $\{1,3\}$, $\{1,3,4\}$, $\{1,2\}$, $\{1,2,4\}$, $\{1,2,3\}$, $\{1,2,3,4\}$

28. 4.92×10^8 years **30.** 4 **32.** $4r - 3$

Chapter 2

Sets, Relations, and Functions

2.1 SET OPERATIONS

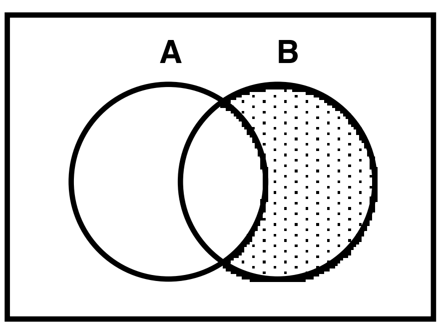
2. $A \cup B = \{1, 2, 4, 5, 6, 7, 9\}$, $A \cap B = \{1, 4, 6, 9\}$, $A - B = \varnothing$, $\overline{A} = \{2, 3, 5, 7, 8\}$, and $\overline{B} = \{3, 8\}$

4. $A \cup B = \{2, 3, 4, 5, 6, 7, 8, 9\}$, $A \cap B = \{7, 9\}$, $A - B = \{3, 4, 6, 8\}$, $\overline{A} = \{1, 2, 5\}$, and $\overline{B} = \{1, 3, 4, 6, 8\}$

6. $\{(3, 1), (3, 2), (3, 3), (4, 1), (4, 2), (4, 3), (5, 1), (5, 2), (5, 3)\}$

8. $\{(p, a), (p, c), (p, e), (q, a), (q, c), (q, e), (r, a), (r, c), (r, e), (s, a), (s, c), (s, e)\}$

10.



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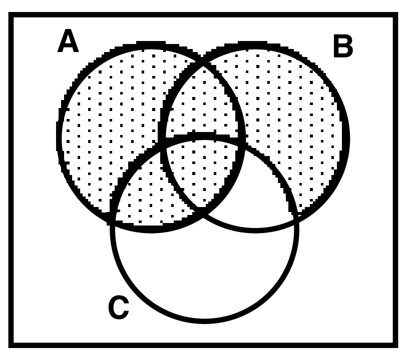


14. $A = \{1, 2\}$, $B = \{1, 3\}$, and $C = \{1\}$

16. $A = \{1, 2\}$, $B = \{1, 3\}$, and $C = \{1\}$

18. A

20. $\varnothing$

22. $A \cap B$

24. $A \cup \overline{B}$

26. The equality $A - B = B - A$ holds if and only if $A = B$.

28. The equality $A \cap B = A$ holds if and only if $A \subseteq B$.

2.2 EQUIVALENCE RELATIONS

2. reflexive and symmetric

4. reflexive, symmetric, and transitive

6. reflexive and symmetric

8. none

10. reflexive and symmetric

12. reflexive and transitive

14. The equivalence class of R containing ABCD consists of the string ABC and the strings of 4 letters having A as their first letter and C as their third letter. There are $26^2 = 676$ distinct equivalence classes of R.

16. The equivalence class of R containing $\{1,\ 2,\ 3\}$ is the set containing the following four elements of S: $\{1,\ 3\}$, $\{1,\ 2,\ 3\}$, $\{1,\ 2,\ 3,\ 4\}$, and $\{1,\ 3,\ 4\}$. There are 8 different equivalence classes of R, namely the sets consisting of the elements S, $S \cup \{2\}$, $S \cup \{4\}$, and $S \cup \{2, 4\}$ for every $S \subseteq \{1, 3, 5\}$.

18. The equivalence class of R containing $(5, 8)$ is the set

$$\{(x_1, x_2)\colon \text{each } x_i \text{ is an integer and } x_1 - x_2 = 5 - 8\}.$$

There are infinitely many distinct equivalence classes of R, namely, the sets of the form

$$\{(x_1, x_2)\colon \text{each } x_i \text{ is an integer and } x_1 - x_2 = k\},$$

where $k = 0, \pm 1, \pm 2, \pm 3, \ldots$.

20. $\{(1,1),(1,3),(1,6),(3,1),(3,3),(3,6),(6,1),(6,3),(6,6),(2,2),(2,5),(5,2),(5,5),(4,4)\}$

24. The equivalence classes have the form $E_1 \times E_2$, where E_i is an equivalence class of R_i.

28. There are 5 partitions of a set with three elements.

32. Let S be a nonempty set and R an equivalence relation on S. Then there is a function f with domain S such that $s_1 \mathrel{R} s_2$ if and only if $f(s_1) = f(s_2)$.

2.3 PARTIAL ORDERING RELATIONS

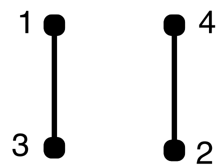
2. not antisymmetric

4. partial ordering

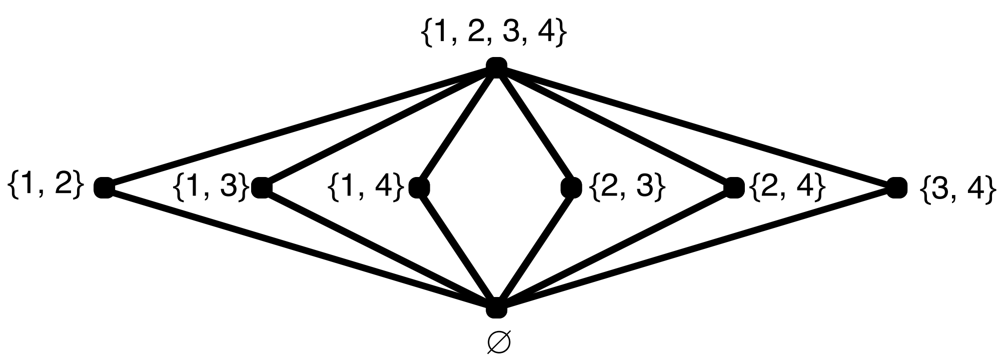
6. not antisymmetric

8. not antisymmetric

10.



12.



14. $R = \{(a,a),(b,b),(b,a),(c,c),(c,b),(c,a),(d,d),(d,a)\}$

16. $R = \{(1,1),(2,2),(2,1),(2,4),(4,4),(8,8),(8,4)\}$

18. The maximal elements are {1}, {2}, and {3}; the only minimal element is {1, 2, 3}.

20. The only minimal element is 0; there are no maximal elements.

22. One possible sequence is 1, 3, 2, 4.

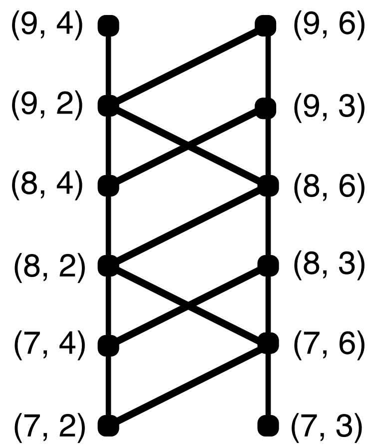
24. One possible sequence is 1, 3, 2, 6, 4, 12.

26. Let S denote the set of residents of Illinois and R be defined so that $x\ R\ y$ means that x is a sister of y.

28. Every prime integer is a minimal element; there are no maximal elements.

30. $(1,1),(1,2),(1,3),(1,4),(2,1),(2,2),(2,3),(2,4),(3,1),(3,2),(3,3),(3,4)$

32.



36. **(a)** Suppose that y is element of S such that $x\ R\ y$ is false. If there is no element y_1 in S such that $y_1\ R\ y$, then y is a minimal element of S, contradicting that x is the unique minimal element of S. Thus there must be such an element y_1. If there is no element y_2 in S such that $y_2\ R\ y_1$, then y_1 is a minimal element of S, another contradiction. So there must be such an element y_2. Because S is finite, continuing in this manner must produce a minimal element y_k of S different from x. Because x is the unique minimal element of S, the assumption that there is an element y of S such that $x\ R\ y$ is false must be incorrect. Thus $x\ R\ s$ is true for every $s \in S$.

(b) Let Z denote the set of integers and $S = Z \cup \{\varnothing\}$. Let R be the relation defined on S by $x\ R\ y$ if and only if one of the following holds: (i) $x, y \in Z$ and $x \leq y$, or (ii) $x = y = \varnothing$. Then $\varnothing$ is the unique minimal element in S, but $\varnothing\ R\ z$ is false for every $z \in Z$.

40. 2^n

42. $2^n \cdot 3^{n(n-1)/2}$