ON-SETS WORKSHEET

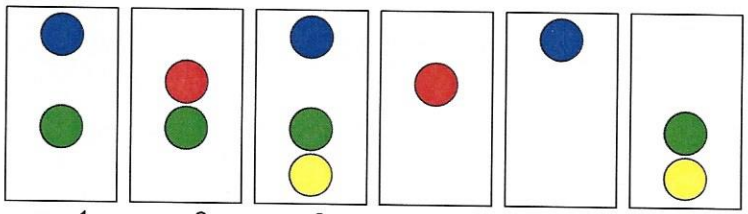
2A

NAME _____

PRINCIPLES

1. V means the Universe; that is, *all* the cards that were dealt.
2. Λ means the empty set; that is, *no* cards.
3. ' behind a set means NOT. So **R'** means "not red."

EXAMPLES



For the Universe above:

Set-Name	Meaning	Number of Cards	Which Cards
V	All the cards	6	1, 2, 3, 4, 5, 6
Λ	No cards	0	none
R'	Cards that are *not* red	4	1, 3, 5, 6
B'	Cards that are *not* blue	3	2, 4, 6

What happens if you put two 's behind the same set, like this? **R''**

Think it out with parentheses, like this: **(R')'**

a. **R'** means the cards that are *not* red. So that's cards 1, 3, 5, and 6 in the Universe above.

b. Then **(R')'** means that cards that are *not* in the set **R'**. That jumps us back to 2 and 4, the red cards.

c. Conclusion: **R'' = R**. That is, two 's cancel each other.

EXERCISES

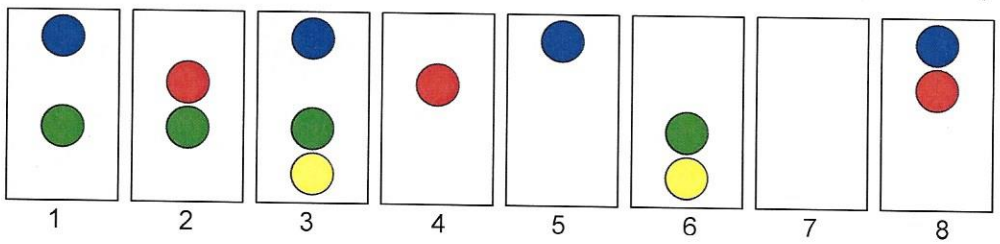
For the Universe above, how many cards are in each set?

1. G ____ **2.** G' ____ **3.** Y ____ **4.** Y' ____ **5.** V' ____ **6.** Λ' ____

7. R'' ____ **8.** B'' ____ **9.** G'' ____ **10.** Y'' ____ **11.** V'' ____ **12.** Λ'' ____

For the Universe below, how many cards are in each set?

Remember The blank card is a card in the Universe. It is *not* in the empty set.



13. B' ____ **14.** R' ____ **15.** G' ____ **16.** Y' ____

17. V ____ **18.** V' ____ **19.** Λ ____ **20.** Λ' ____

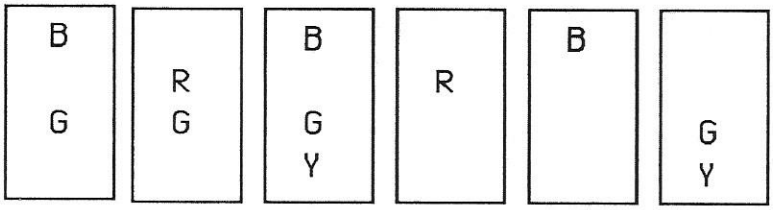
ON-SETS WORKSHEET

2B

NAME _____

PRINCIPLE
X ∪ Y (read "X union Y" or "the union of X and Y") is the set of all cards in the Universe that are in either X or Y (or both).

EXAMPLES



For the Universe above,

Set-Name	Number of Cards	Which Cards
B ∪ R	5	1, 2, 3, 4, 5
G ∪ Y	4	1, 2, 3, 6
B' ∪ G	5	1, 2, 3, 4, 6
R' ∪ Y'	6	1, 2, 3, 4, 5, 6
B ∪ △	3	1, 3, 5
R ∪ V	6	1, 2, 3, 4, 5, 6

EXERCISES

For the Universe above, how many cards are in each set?

1. B ∪ G	_____	2. R ∪ Y	_____	3. B ∪ Y	_____
4. G' ∪ R	_____	5. B' ∪ R	_____	6. G ∪ △	_____
7. V ∪ Y	_____	8. B' ∪ Y'	_____	9. G' ∪ R'	_____
10. B ∪ B	_____	11. B ∪ R ∪ G	_____	12. R ∪ G ∪ Y	_____
13. B' ∪ G ∪ R	_____	14. R' ∪ G' ∪ Y	_____	15. B' ∪ Y ∪ G'	_____
16. R ∪ R'	_____	17. B' ∪ B	_____	18. B ∪ G ∪ △	_____

MORE CHALLENGING EXERCISES

Circle the number of each statement that is true for any sets X and Y.

19. X ∪ X = X
20. X ∪ Y = Y ∪ X
21. X ∪ V = X
22. X ∪ △ = X
23. X' ∪ Y = X ∪ Y'
24. X ∪ X' = V

ON-SETS WORKSHEET

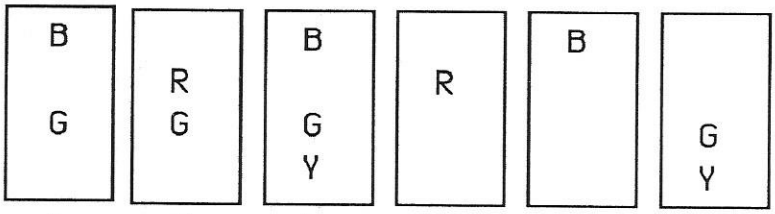
2C

NAME _____

PRINCIPLE

X ∩ Y (read "X intersect Y" or "the intersection of X and Y") is the set of cards in the Universe that are in <u>both</u> X and Y.

EXAMPLES



For the Universe above,

Set-Name	Number of Cards	Which Cards
B ∩ G	2	1, 3
B ∩ R	0	none
B' ∩ Y	1	6
R' ∩ Y'	2	1, 5
B ∩ △	0	none
R ∩ V	2	2, 4
B ∩ G ∩ Y	1	3
(B ∪ R) ∩ G	3	1, 2, 3
R' ∩ (G ∪ Y)	3	1, 3, 6

EXERCISES

For the Universe above, how many cards are in each set?

1. B ∩ G _____
2. R ∩ Y _____
3. B ∩ Y _____
4. G' ∩ R _____
5. B' ∩ R _____
6. G ∩ △ _____
7. V ∩ Y _____
8. B' ∩ Y' _____
9. G' ∩ R' _____
10. B ∩ B _____
11. B ∩ R ∩ G _____
12. R ∩ (G ∪ Y) _____
13. (B' ∪ G) ∩ R _____
14. (R' ∩ G') ∪ Y _____
15. B' ∩ Y' ∩ G _____
16. R ∩ R' _____
17. B' ∩ B _____
18. B ∩ G ∩ △ _____

MORE CHALLENGING EXERCISES

Circle the number of each statement that is true for any sets X and Y.

19. X ∪ X = X
20. X ∩ Y = Y ∩ X
21. X ∩ V = X
22. X ∩ △ = X
23. X' ∩ Y = X ∩ Y'
24. X ∩ X' = V

ON–SETS WORKSHEET

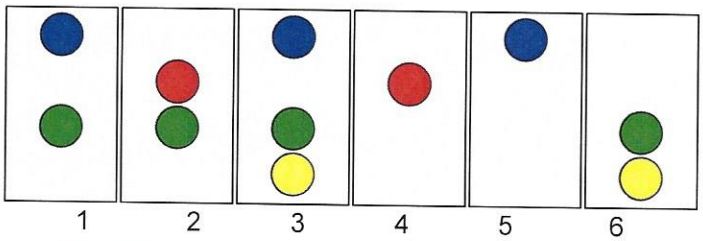
2D

NAME _____

PRINCIPLE

For any sets X and Y, **X – Y** (read "X minus Y" or "X without Y") is the set of all cards in the Universe that are **in X but not in Y**.

EXAMPLES



1. For the Universe above, **B – G** is worked out as follows.
   - **a.** Start with the set of **B** cards; that is, cards 1, 3, and 5.
   - **b.** From the set of **B** cards, subtract (remove) any that are **G**. So remove cards 1 and 3.
   - **c.** So **B – G** = 1, card 5. That's the only card that is **B** but not **G**.

   Notice that cards 2 and 6, which are **G**, are not involved since they are not **B**.
2. Here's how **Y' – R** is worked for the Universe above.
   - **a.** Start with the set of **Y'** cards; that is, cards 1, 2, 4, and 5.
   - **b.** From the set of **Y'** cards, remove any that are **R**. So remove cards 2 and 4.
   - **c.** So **Y' – R** is 2, cards 1 and 5. Those are the cards that are **Y'** but not **R**.
3. Work out **G – R'** like this.
   - **a.** Start with the **G** cards – 1, 2, 3, and 6.
   - **b.** Remove all **G** cards that are *not* **R**. So remove cards 1, 3, and 6.
   - **c.** That leaves just card 2. So **G – R'** = 1.

EXERCISES

For the Universe above, how many cards are in each set?

1. B – R ____	2. B – Y ____	3. R – B ____	4. R – G ____
5. R – Y ____	6. G – B ____	7. G – R ____	8. G – Y ____
9. Y – B ____	10. Y – R ____	11. Y – G ____	12. B – R' ____
13. B – G' ____	14. R – B' ____	15. R – Y' ____	16. G – B' ____
17. G – Y' ____	18. B' – G ____	19. B' – Y ____	20. R' – B ____
21. R' – G ____	22. Y' – B ____	23. Y' – G ____	24. G' – R' ____
25. G' – Y' ____	26. R' – B' ____	27. R' – G' ____	28. Y' – B' ____
29. V – B ____	30. V – R ____	31. V – G' ____	32. V – Y' ____
33. B – V ____	34. G' – V ____	35. Λ – G ____	36. Λ – Y' ____
37. R – R ____	38. Y' – Y' ____	39. G – Λ ____	40. B' – Λ ____

*What **set** does each of the following equal for **any** Universe?*

41. V – G ____	42. Y' – V ____	43. R – Λ ____	44. Λ – B' ____

ON-SETS WORKSHEET

2E

NAME _____

PRINCIPLES

The **order of operations** in On-Sets is as follows.

1. Operations within parentheses (or brackets) are done first, from the innermost parentheses outward.
2. Any complements (') are done from left to right.
3. Union, intersection, and subtraction are equal in standing. Parentheses must be used to show the order among them.

EXAMPLES

1. In the expression R ∪ G', the G' is done first, then the ∪. Thus R ∪ G' is the same as R ∪ (G') and the same as G' ∪ R. If the player writing this Set-Name wants the U done first, parentheses must be used: (R ∪ G)'.
2. Consider the expression (Y ∩ R') − G.
   a. The set within parentheses must be worked out first. However, the parentheses contain two operations: ∩ and '. Because of the built-in order of operations, ' is done first, then ∩.
   b. After the set in parentheses has been determined, the last operation, −, is performed.

   The order of operations can be indicated like this: (Y ∩ R') − G.
   ② ① ③
3. What is the order of operations in [R' ∪ (V − B)] − Y?
   The numbers show the order. [R' ∪ (V − B)] − Y
   ②③ ① ④

EXERCISES

Write numerals under each expression to show the order of operations.

1. G ∪ Y'
2. Δ' − B
3. R' − G'
4. (G' ∪ Y) ∩ R
5. B ∪ (Y − G)'
6. (B'' − G) ∪ Δ
7. (B ∪ Y) − G'
8. B'' − (G ∪ Δ)
9. [Y ∪ (G−R)]−Y
10. [(V − R) ∩ Y]' ∪ B
11. Y ∪ [(G − R) − Y]
12. (V−R)∪(Y'∪B)

MORE CHALLENGING EXERCISES

13. (B' − G') ∪ (R ∩ Y)
14. [(R ∪ G) − (V − B)]'
15. B''' ∪ (R − G')

ON-SETS WORKSHEET

2F

NAME _____

PRINCIPLE

A Set-Name that may be interpreted in more than one way is **ambiguous.** An opponent may put parentheses anywhere that makes sense in an ambiguous Set-Name in order to produce a set that does not contain the number of cards in the Goal.

EXAMPLES

1. R ∪ G - B is an ambiguous expression. "Ambiguous" means "having several possible meanings or interpretations." According to the order of operations of On-Sets, ∪ and - are equal in priority. Therefore, either one may be worked out first. Thus, R ∪ G - B could mean (R ∪ G) - B or R ∪ (G - B). For most Universes the number of cards in these two sets would be different. If the player writing this Set-Name does not put parentheses, an opponent may interpret the expression in whichever way would make it not have the number of cards in the Goal.
2. An expression like R ∪ B ∪ G is not ambiguous. Both interpretations, (R ∪ B) ∪ G and R ∪ (B ∪ G), contain the same cards.
3. The expression R ∩ Y' is not ambiguous. According to the order of operations, ' is always done before ∩. Therefore, an opponent may not interpret the expression as (R ∩ Y)'.

EXERCISES

Circle the number of each ambiguous expression.

1. B ∪ G'	2. R' - Y'	3. (R' - Y)'
4. B - Y ∪ G	5. R ∩ G - ∆	6. (B ∪ V) - Y ∪ G
7. R ∩ B ∩ Y	8. B ∩ G ∪ R'	9. (B ∪ R - G) ∪ Y

MORE CHALLENGING EXERCISES

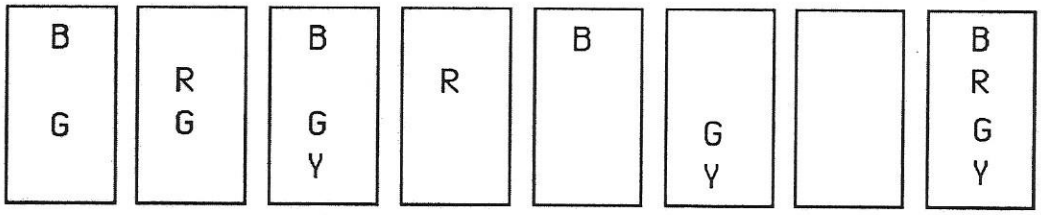
10. In the space below, recopy each ambiguous expression of Exercises 1-9. Add parentheses or brackets to the expression to show each possible interpretation.

ON-SETS WORKSHEET

2G

NAME _____

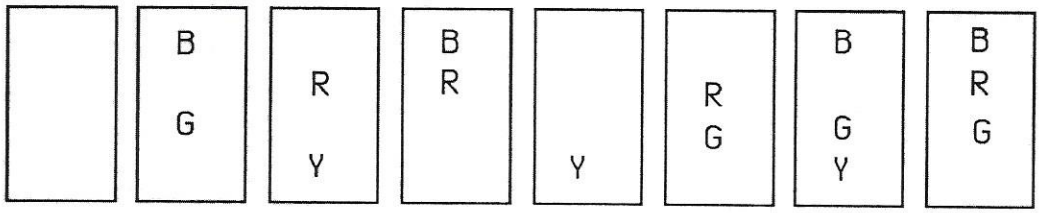
EXERCISES



For the Universe above, give the number of cards in each set.

1. G - Y _____	2. $\underline{\vee}$ - R _____	3. G $\underline{\cup}$ Y' _____
4. R - Y' _____	5. (R $\underline{\cup}$ Y) - B _____	6. R $\cap$ (Y - B) _____
7. (R $\cap$ G)' _____	8. (B $\cap$ R) - Y' _____	9. B $\cap$ (R - Y') _____
10. B' $\underline{\cup}$ R' _____	11. (R' $\cap$ B') $\underline{\cup}$ $\underline{\vee}$ _____	12. R' $\cap$ Y' _____
13. $\underline{\wedge}$ $\cap$ (G' - Y') _____	14. (B $\underline{\cup}$ R) - Y' _____	15. $\underline{\vee}$ - (Y $\underline{\cup}$ G) _____
16. R - (G - B) _____	17. (R - G) - B _____	18. Y' - (B $\cap$ R) _____
19. (Y $\cap$ G) $\underline{\cup}$ (B$\cap$R) _____		20. (R - B) $\underline{\cup}$ (B - G) _____
21. [G $\cap$ (B - $\underline{\vee}$)] $\underline{\cup}$ Y' _____		22. R $\underline{\cup}$ [G - (B - Y)] _____

MORE CHALLENGING EXERCISES



For the Universe above, the given expression is intended to name a set containing the number of cards listed. If the expression is ambiguous, add parentheses or brackets so that it does not give the desired number of cards. If there is no way to misinterpret the expression, write *no way*.

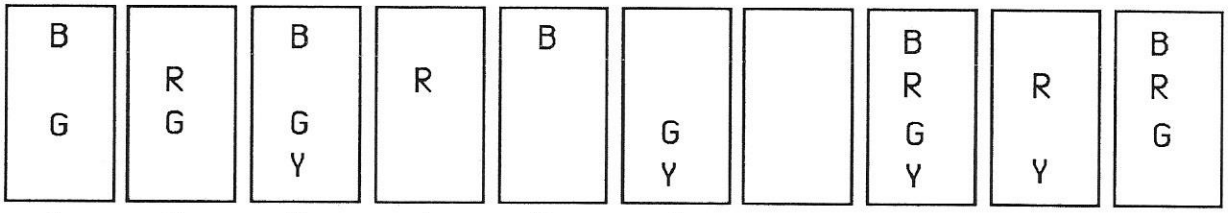
	No. of cards	Expression		No. of cards	Expression
23.	2	B $\underline{\cup}$ R - G	24.	2	B - R'
25.	4	B - G $\underline{\cup}$ R	26.	3	Y' - R'
27.	4	(R $\underline{\cup}$ G)' $\underline{\cup}$ B - Y	28.	2	B - ($\underline{\vee}$ - R)''
29.	0	B $\cap$ (R $\underline{\cup}$ G - $\underline{\vee}$)	30.	2	(B - R) - G' $\underline{\cup}$ $\underline{\wedge}$

ON-SETS WORKSHEET

2H

NAME _____

MORE CHALLENGING EXERCISES



For the Universe above, write a Set-Name for the set of cards listed. Choose from the Resources B, R, G, Y, and '.

1. 4,5,7,9 _____
2. 2,4,6,7,9 _____
3. 1,3,5,6,7 _____
4. 1,2,4,5,7,10 _____

Write a Set-Name for the set of cards listed. Choose from the Resources B, R, G, Y, ∪, and '.

5. All except 9 _____
6. 6,7 _____
7. 1,5,7 _____
8. 4,5,7 _____
9. 5,7 _____
10. All except 5 _____
11. 1,3,4,5,7,8,9,10 _____
12. 4,7,9 _____
13. 1,3,5,6,7,8,9 _____
14. 1,3,5,6,7,8,10 _____

Repeat the directions for Exercises 5-14. However, now you may use ∪ and ' in a Set-Name multiple times.

15. All except 8,10 _____
16. All except 7 _____
17. 1,3,5 _____
18. All except 2,10 _____
19. All except 4,7 _____
20. All the cards _____
21. 7 only _____
22. 1,2,4,5,7,9,10 _____

Write a Set-Name that contains the cards listed. Choose from the Resources R, B, G, Y, ∩, and '.

23. 1,3,5 _____
24. All except 8,10 _____
25. 2,4,9 _____
26. 2,4,5,6,7,9 _____
27. 9 _____
28. 1,3,4,5,6,7,9 _____
29. 1,2,10 _____
30. All except 8,9 _____

Repeat the directions for Exercises 23-30. However, now you may use ' in a Set-Name multiple times.

31. 6,7 _____
32. 1,5,7 _____
33. 4,7,9 _____
34. 4,5,7 _____

Write a Set-Name that contains the cards listed. Choose from the Resources R, B, G, Y, ∪, ∩, and '.

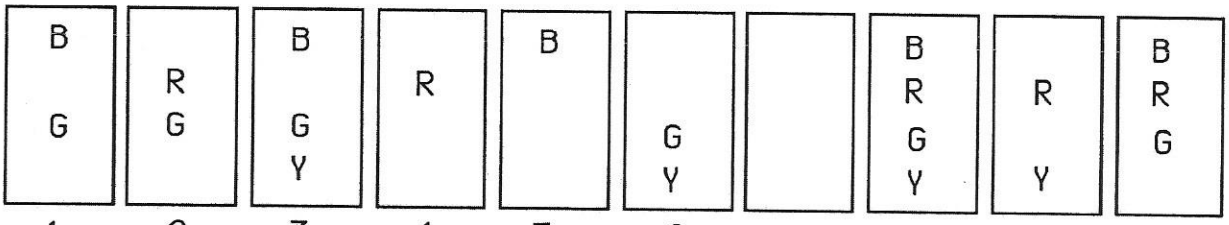
35. 4,5,9 _____
36. 1,3,5,6,7,8 _____
37. 3,5,6,7,8,9 _____
38. 1,5 _____

ON-SETS WORKSHEET

21

NAME _____

MORE CHALLENGING EXERCISES



For the Universe above, write a Set-Name for the set of cards listed. Choose from the Resources B, R, G, Y, and -.

1. 1,3,5 _____
2. 4,9 _____
3. 9 _____
4. 1,5,10 _____

Write a Set-Name for the set of cards listed. Choose from the Resources B, R, G, Y, -, and '.

5. 5,7 _____
6. 6,7 _____
7. 3,8 _____
8. 4,7,9 _____
9. 2,8,10 _____
10. 8,9 _____
11. 2,4,7 _____
12. 3,6,8 _____

Repeat the directions for Exercises 5-12. However, now you may use - and ' in a Set-Name multiple times.

13. 2,4,9 _____
14. 9 _____
15. 4,8,9 _____
16. 1,5,10 _____
17. 2,4 _____
18. 2 _____

Write a Set-Name that contains the cards listed. Choose from the Resources R, B, G, Y, $\cap$, $\cup$, -, and '.

19. All except 2,6 _____
20. 1,2,4,5,10 _____
21. 1,3,6 _____
22. 2,10 _____
23. 1,2,3,6,10 _____
24. 8,9,10 _____
25. 1,3,5,8,9,10 _____
26. 4,6,7,9 _____

Circle the number of each statement that is true for <u>any</u> Universe.

27. $B - R = B \cap R'$
28. $(B \cup R) - B = R$
29. $B - R = B - (B \cap R)$
30. $B - R = B - (\underline{V} \cap R)$
31. $(B - R) - \Delta = B - (R - \Delta)$
32. $(\underline{V} - B) - R = \underline{V} - (B - R)$
33. $B' - R' = (B - R)'$
34. $B \cup (R - B) = B \cup R$
35. $G - G' = G$
36. $Y' - Y = Y$
37. $\Delta - (R \cup G) = \Delta$
38. $\underline{V} - B' = B$
39. $(Y \cup G') - \underline{V} = \Delta$
40. $Y' - Y' = \Delta$

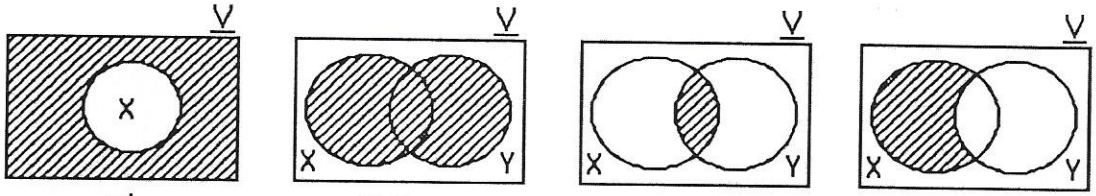
ON-SETS WORKSHEET

2J

NAME _____

PRINCIPLE
Operations with sets can be shown by **Venn diagrams.**

In a Venn diagram a rectangle represents the Universal set and circles inside the rectangle stand for sets within the Universe.

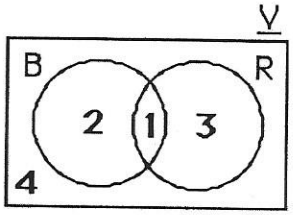


X' X ∪ Y X ∩ Y X − Y

In each case the shaded region represents the set named below the diagram.

EXERCISES

Complete each of these exercises, which refer to the Venn diagram at the right. The first one is done for you as an example.



	Region(s) Shaded	Set
	1, 2, and 3 only	B ∪ R
1.	_____	B ∩ R
2.	2 only	_____
3.	_____	R ∩ B'
4.	3 and 4 only	_____
5.	_____	B − ∧
6.	_____	R' ∩ V
7.	1, 3, and 4 only	_____
8.	_____	B' ∪ B
9.	_____	R − R'
10.	_____	V − B'
11.	4 only	_____
12.	_____	R''

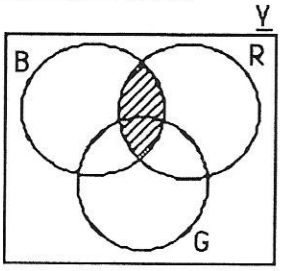
ON-SETS WORKSHEET

2K

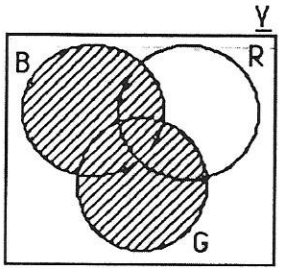
NAME _____

PRINCIPLE
The relationships among three sets can be shown by a Venn diagram.

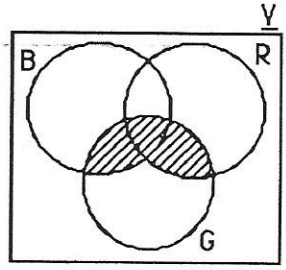
EXAMPLES



B ∩ R



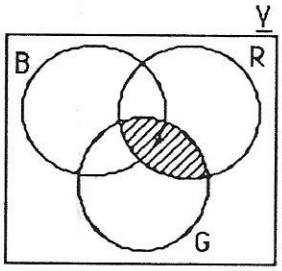
B ∪ G



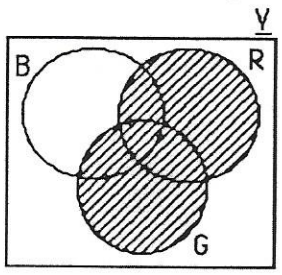
(B∩G) ∪ (R∩G)

MORE CHALLENGING EXERCISES

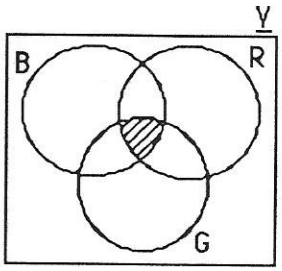
Write a Set-Name for the shaded region in each diagram.



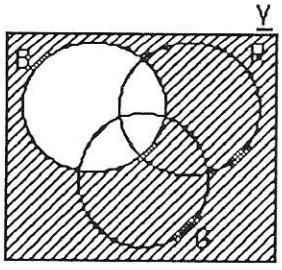
1. _____



2. _____



3. _____



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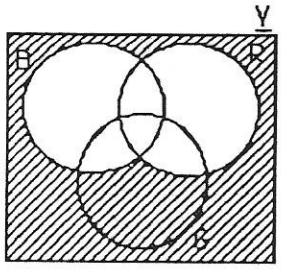

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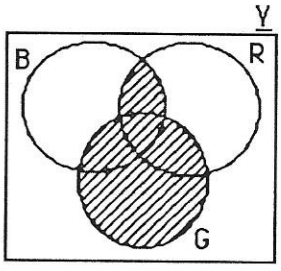
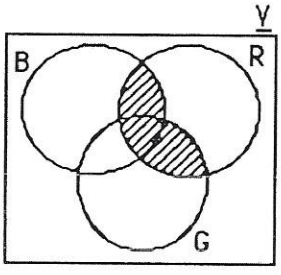
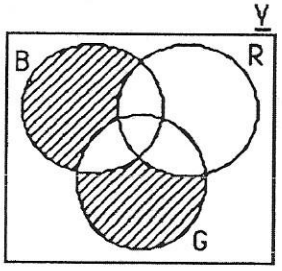


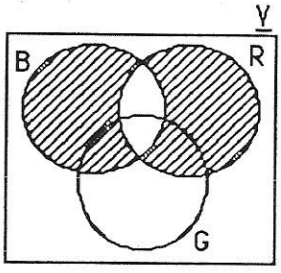
6. _____



7. _____



8. _____



9. _____

ON-SETS WORKSHEET

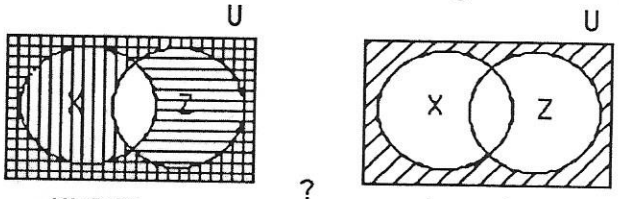
2L

NAME _____

PRINCIPLES

The first DeMorgan Law states:
For any sets X and Z, $X' \cap Z' = (X \cup Z)'$.
In words, "the intersection of the complements of the sets is the complement of the union of the two sets."
The second DeMorgan Law states:
For any sets X and Z, $X' \cup Z' = (X \cap Z)'$.
In words, "the union of the complements of two sets is the complement of the intersection of the two sets."

The first DeMorgan Law can be checked by Venn diagrams.



$X' \cap Z'$? = $(X \cup Z)'$

In the diagram on the left, X' is shaded across while Z' is shaded up and down. Where the two shadings cross is $X' \cap Z'$. This is the region outside both circles, which matches the region shaded in the diagram on the right.

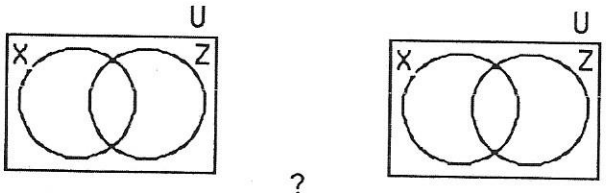
What good are these laws in On-Sets? $B' \cap R'$ involves three operations; $(B \cup R)'$ contains only two. So if the set to be determined is $B' \cap R'$, it is quicker to work out $(B \cup R)'$. With one fewer operation, the chance of error is reduced.

MORE CHALLENGING EXERCISES

Use DeMorgan's Laws to rewrite each expression and reduce the number of operations by one each time.

1. $B' \cap Y'$ _____
2. $R' \cap Y'$ _____
3. $Y' \cup R'$ _____
4. $G' \cup Y'$ _____
5. $(B \cup R)' \cup G'$ _____
6. $R' \cap (Y \cup G)'$ _____

7. Shade the Venn diagrams below to show the truth of the second DeMorgan Law.



$X' \cup Z'$? = $(X \cap Z)'$

ON-SETS WORKSHEET

2M

NAME _____

THE PRINCIPLE OF DUALITY
If a given statement holds true about sets, then another true statement is obtained by interchanging $\cup$ and $\cap$ and interchanging $\vee$ and $\wedge$ throughout the original statement.

EXAMPLES

	Statement	Dual-Statement
1.	$B \cup G = G \cup B$	$B \cap G = G \cap B$
	($\cup$ becomes $\cap$)	
2.	$R \cup \wedge = R$	$R \cap \vee = R$
	($\vee$ becomes $\wedge$)	
3.	$Y \cap Y' = \wedge$	$Y \cup Y' = \vee$
4.	$\vee \cup R' = \vee$	$\wedge \cap R' = \wedge$

EXERCISES

Write the dual of each statement.

1. $R \cup R = R$ _____
2. $B \cap \wedge = \wedge$ _____
3. $G' \cup G = \vee$ _____
4. $(B \cup Y)' = B' \cap Y'$ _____
5. $Y' \cap G = G \cap Y'$ _____
6. $R \cup (R \cap G) = R$ _____
7. $B \cup (Y \cap G) = (B \cup Y) \cap (B \cup G)$ _____
8. $G' \cup (Y \cup R) = (G' \cup Y) \cup R$ _____

MORE CHALLENGING EXERCISES

Does the Principle of Duality apply to the - operation? To answer this question, write the "dual" of each of the following true statements. Replace $\vee$ with $\wedge$ and vice-versa. Is the "dual" true or false?

Statement	"Dual"	True/False?
9. $R - \wedge = R$	_____	_____
10. $G - \vee = \wedge$	_____	_____
11. $\vee - Y = Y'$	_____	_____

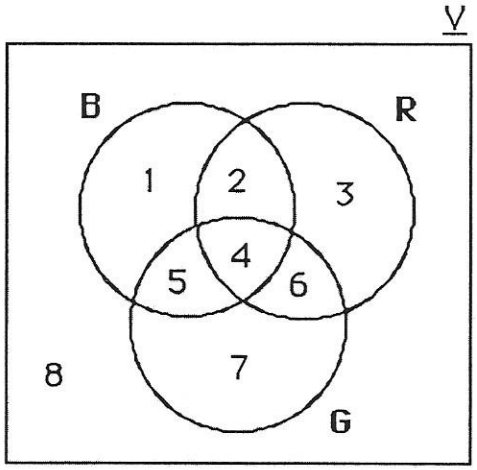
12. Does the Principle of Duality apply to the - operation? _____

On-Sets Worksheet

2N

Name _____

Venn Diagrams



Give a set name for each numbered region in the diagram above. #1 is done for you as an example.

1 B – (R ∪ G) **2** _____

3 _____ **4** _____

5 _____ **6** _____

7 _____ **8** _____

List the number(s) of all the regions in the diagram above that correspond to each set.

Sample R ∪ G **Answer** 2, 3, 4, 5, 6, 7

9 B ∪ R _____ **10** B – R _____

11 G – R _____ **12** B – G' _____

13 G' Ω B _____ **14** B' Ω R' _____

15 (B ∪ G) – R _____ **16** (R ∪ G) – B' _____

17 (B Ω R) – G' _____ **18** (R Ω G) – B' _____

19 (B – R) – G _____ **20** B – (R – G) _____

21 (G – R') – B _____ **22** G – (R' – B) _____

23 (R – B) ∪ G _____ **24** (B ∪ G)' – R _____