Set notation

97 marks

Hints online, answers free with an account: mathswariz.uk/worksheets/a-level-statistics-year-2-set-notation/

Date

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A Do Now

Quick questions to start. Some use earlier lessons; some set a slip that costs marks in the exam.

A1 Needed today [3 marks]

In a group of 40 students, 22 study biology, 15 study chemistry and 6 study both. Find the number of students who study neither subject, and the probability that a student chosen at random studies exactly one of the two subjects.

Answer .....

A2 Needed today [3 marks]

A and B are independent events with $\mathrm{P}(A) = 0.4$ and $\mathrm{P}(B) = 0.25$. Find the probability that both happen, and the probability that neither happens.

Answer .....

A3 Common slip [2 marks]

R is the event "it rains" and W is the event "it is windy". Lily writes "$R \cap W' = 0.2$". Write down what she should have written, and describe the event $R \cap W'$ in words.

Answer .....

A4 Common slip [2 marks]

A Venn diagram of probabilities for two events shows 0.3 in A only, 0.15 in both and 0.35 in B only. Nothing is written outside the circles. Find the probability outside both circles, and find $\mathrm{P}(A')$.

Answer .....

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PART 1 Regions in set notation

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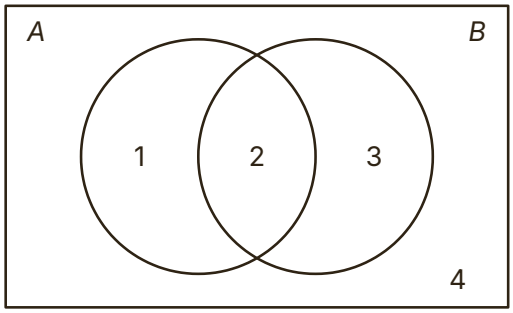
EXAMPLE 1 · I DO

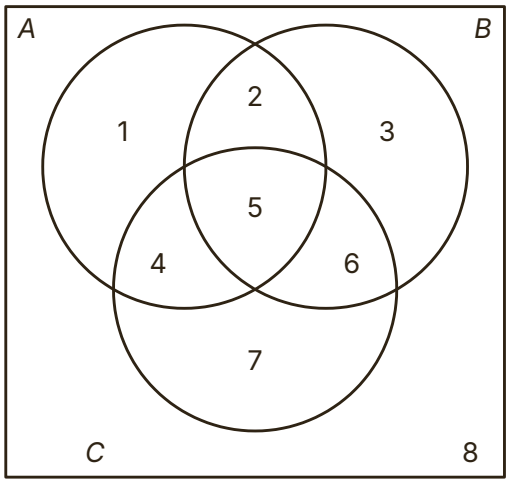
The four regions of this Venn diagram are numbered 1 to 4. (a) Write each region in set notation. (b) List the regions that make up $A \cup B'$, $(A \cap B)'$ and $A' \cap B'$. (c) Explain why $(A \cup B)'$ and $A' \cap B'$ are the same region.



Hint $\cap$ means "and" (in both), $\cup$ means "or" (in at least one), and A' means "not in A". For a union, list the regions of each part and put the lists together.

YOUR TURN · WE DO

B1 The eight regions of this Venn diagram are numbered 1 to 8.



(a) List the regions that make up $A \cap B \cap C'$. [1 mark]

Answer .....

(b) List the regions that make up $(A \cup B) \cap C$. [1 mark]

Answer .....

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(c) List the regions that make up $A' \cap (B \cup C)$. [1 mark]

Answer .....

(d) Regions 1, 3 and 7 make the event "exactly one of A, B, C happens". Write this event in set notation. [1 mark]

Answer .....

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(e) Write region 8 in set notation in two different ways. [1 mark]

PRACTICE · YOU DO

C1 For a student chosen at random, S is the event "studies Spanish" and E is the event "studies economics". $\mathrm{P}(S) = 0.4$, $\mathrm{P}(E) = 0.3$ and $\mathrm{P}(S \cap E) = 0.1$. Sam writes: "$S \cap E' = 0.3$. The probability that a student studies Spanish or economics is $\mathrm{P}(S \cap E) = 0.1$." Explain the two mistakes in Sam's work. Find $\mathrm{P}(S \cup E)$ and $\mathrm{P}(S' \cap E')$. [5 marks]

Answer .....

Total for B1: 5 marks

Answer .....

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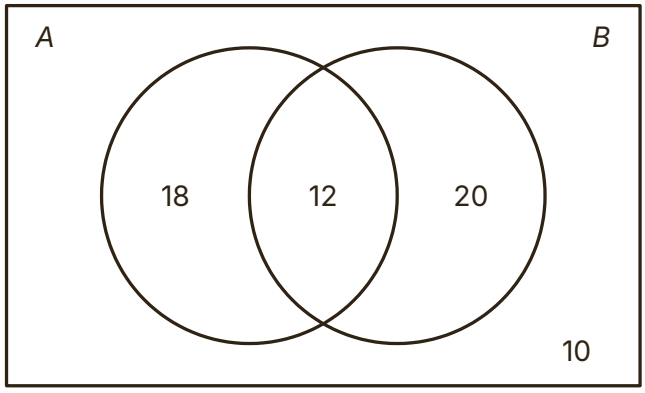
C2 60 people were asked about two events. The Venn diagram shows the numbers. Mo says: "$\mathrm{P}((A \cap B)') = \mathrm{P}(A' \cap B') = \frac{10}{60}$." Explain Mo's mistake. Find $\mathrm{P}((A \cap B)')$ and $\mathrm{P}(A' \cap B')$, and name one other set expression with the same probability as $(A \cap B)'$. [5 marks]



Answer .....

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PART 2 Probabilities from a Venn diagram

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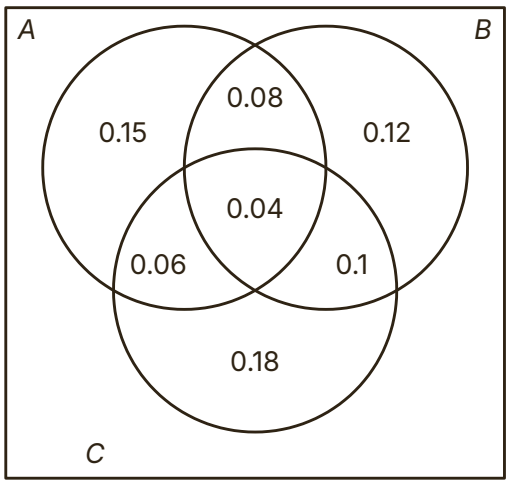
EXAMPLE 2 · I DO

An integer is chosen at random from the integers 1 to 40. A is the event "the integer is a multiple of 4" and B is the event "the integer is a multiple of 6". Find $n(A)$, $n(B)$ and $n(A \cap B)$, and then find $\mathrm{P}(A \cup B)$, $\mathrm{P}(A' \cap B)$ and $\mathrm{P}((A \cup B)')$.

Hint A multiple of both 4 and 6 is a multiple of 12. Draw a Venn diagram of counts, then divide by the 40 equally likely outcomes.

YOUR TURN · WE DO

B2 The Venn diagram shows the probabilities of three events A, B and C. The probability outside all three circles is not shown. Find



(a) $\mathrm{P}(A' \cap B' \cap C')$ [2 marks]

Answer .....

(b) $\mathrm{P}(A \cap B')$ [1 mark]

Answer .....

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(c) $\mathrm{P}(A \cup C)$ [1 mark]

Answer .....

(d) $\mathrm{P}((A \cap B) \cup C')$ [1 mark]

Answer .....

(e) $\mathrm{P}((A \cup B) \cap C')$ [1 mark]

Answer .....

Total for B2: 6 marks

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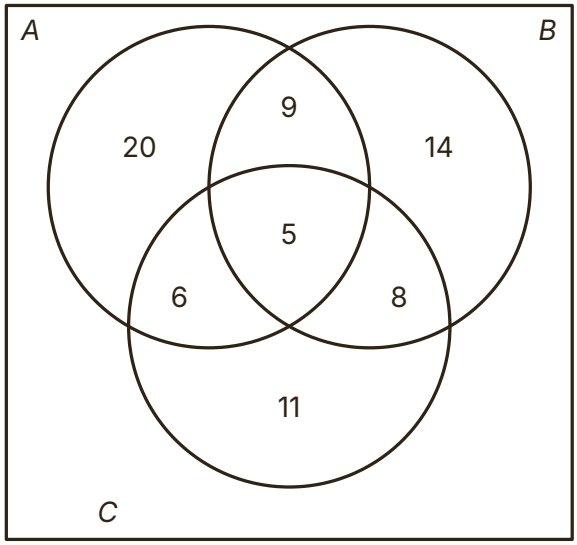
C3 90 people were asked which of three magazines A, B and C they read. The Venn diagram shows the numbers. Ella writes: "$\mathrm{P}(A' \cap B' \cap C') = 0$ because no number is written outside the circles." Explain why Ella is wrong. Find $\mathrm{P}(A' \cap B' \cap C')$, the probability that a person chosen at random reads exactly one of the magazines, and $\mathrm{P}(B \cap (A \cup C)')$. [5 marks]



Answer .....

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C4 Two fair six-sided dice are rolled. A is the event "the total is 9 or more", B is the event "the dice show the same number" and C is the event "at least one die shows a 6". Find $n(A \cap B)$, $\mathrm{P}(A \cup B)$, $\mathrm{P}(A \cap B \cap C)$, $\mathrm{P}((A \cup B) \cap C')$ and $\mathrm{P}(A' \cap B' \cap C')$. [6 marks]

Answer .....

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PART 3 Independent and mutually exclusive events

EXAMPLE 3 · I DO

$\mathrm{P}(A) = 0.35$, $\mathrm{P}(B) = 0.5$ and $\mathrm{P}(A \cap B) = 0.15$. (a) Show that A and B are not independent. A third event C has $\mathrm{P}(C) = 0.3$. A and C are mutually exclusive, and B and C are independent. (b) Draw a Venn diagram of probabilities for A, B and C. (c) Find $\mathrm{P}(B \cap C')$, $\mathrm{P}((A \cup C)')$ and $\mathrm{P}((A \cap B') \cup C)$.

Hint Mutually exclusive means $A \cap C = \varnothing$, so A and C do not overlap at all. Independent means $\mathrm{P}(B \cap C) = \mathrm{P}(B)\,\mathrm{P}(C)$. Fill the overlaps first, then each "only" region, then the outside.

YOUR TURN · WE DO

B3 $\mathrm{P}(J) = 0.35$, $\mathrm{P}(K) = 0.4$, $\mathrm{P}(L) = 0.25$ and $\mathrm{P}(J \cap K) = 0.12$. J and L are mutually exclusive, and K and L are independent. Draw a Venn diagram of probabilities for J, K and L. Find $\mathrm{P}(J \cup K)$, $\mathrm{P}(J' \cap L')$ and $\mathrm{P}((J \cup L) \cap K')$. [7 marks]

Answer .....

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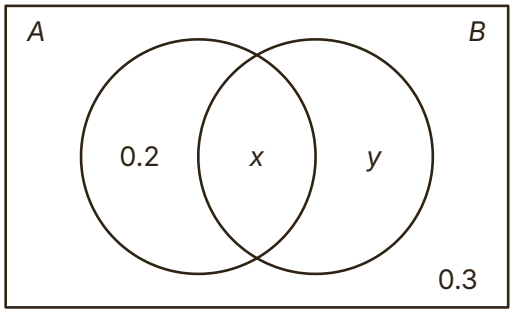
EXAMPLE 4 · I DO

(i) The Venn diagram shows the probabilities for two events A and B. Given that A and B are independent, find x and y, and then find $\mathrm{P}(A \cup B')$. (ii) C and D are independent events with $\mathrm{P}(C) = c$ and $\mathrm{P}(D) = d$. Show that $\mathrm{P}(C' \cap D') = (1-c)(1-d)$, and hence write $\mathrm{P}(C \cup D)$ in terms of c and d.



Hint (i) Two equations: the regions add to 1, and $\mathrm{P}(A \cap B) = \mathrm{P}(A)\,\mathrm{P}(B)$. (ii) $C' \cap D' = (C \cup D)'$, and $\mathrm{P}(C \cup D) = \mathrm{P}(C) + \mathrm{P}(D) - \mathrm{P}(C \cap D)$.

YOUR TURN · WE DO

B4 A and B are independent events with $\mathrm{P}(A) = x$ and $\mathrm{P}(B) = y$.

(a) Find, in terms of x and y, $\mathrm{P}(A \cup B')$ and $\mathrm{P}((A \cap B') \cup (A' \cap B))$. [4 marks]

Answer .....

(b) Given that $x = 0.3$ and $\mathrm{P}(A \cup B') = 0.79$, find y. [2 marks]

Answer .....

Total for B4: 6 marks

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C5 $\mathrm{P}(A) = 0.5$, $\mathrm{P}(B) = 0.35$ and $\mathrm{P}(A' \cap B') = 0.25$. Jo writes: "$\mathrm{P}(A \cup B) = 0.5 + 0.35 = 0.85$, so $\mathrm{P}(A' \cap B') = 0.15$, so the question is wrong." Explain Jo's mistake. Find $\mathrm{P}(A \cap B)$ and $\mathrm{P}(A \cap B')$, and determine whether A and B are independent. [6 marks]

Answer .....

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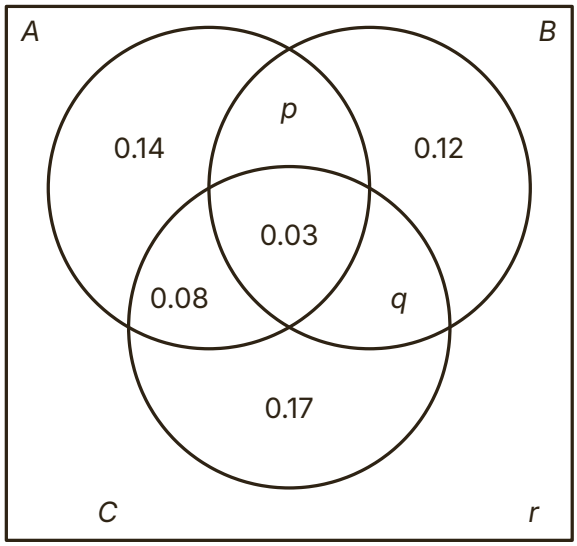
C6 The Venn diagram shows the probabilities for three events A, B and C, where p, q and r are probabilities. Given that $\mathrm{P}(C) = 0.4$ and $\mathrm{P}((A \cup B) \cap C') = 0.42$, find p, q and r, and determine whether the events A and C are independent. [8 marks]



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Answer .....

D Exam-style questions

Edexcel exam style

D1 $\mathrm{P}(A) = 0.42$, $\mathrm{P}(B) = 0.3$ and $\mathrm{P}(A \cup B) = 0.6$. A third event C has $\mathrm{P}(C) = 0.25$. The events B and C are mutually exclusive, and the events A and C are independent.

(a) Find $\mathrm{P}(A \cap B)$ and show that A and B are not independent. [3 marks]

Answer .....

(b) Draw a Venn diagram to show the probabilities of A, B and C. [4 marks]

Answer .....

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(c) Find $\mathrm{P}((A \cup C)')$. [2 marks]

Answer .....

(d) Find $\mathrm{P}((A \cap C') \cup (B' \cap C))$. [2 marks]

Answer .....

Total for D1: 11 marks

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D2

> $\mathrm{P}(A) = 0.55$, $\mathrm{P}(B) = 0.4$ and $\mathrm{P}((A \cap B)') = 0.78$. Kai writes: "$\mathrm{P}(A' \cap B') = 0.78$, so $\mathrm{P}(A \cup B) = 0.22$. So $\mathrm{P}(A \cap B) = 0.55 + 0.4 - 0.22 = 0.73$."

Kai is wrong.

(a) Explain why Kai's value of $\mathrm{P}(A \cap B)$ cannot be right, without finding the correct value. [2 marks]

(b) Identify Kai's mistake. Find the correct values of $\mathrm{P}(A \cap B)$ and $\mathrm{P}(A \cup B)$. [3 marks]

Answer .....

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(c) Find $\mathrm{P}(A' \cap B')$, and determine whether A and B are independent. [4 marks]

Answer .....

Total for D2: 9 marks

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E Extension

Stretch

No route is given. The hints are at the end of the sheet. Use one at a time.

E1 Three events A, B and C each have probability $\frac{1}{2}$. Each pair of them is independent, and $\mathrm{P}(A \cap B \cap C) = p$.

(a) Show that $\mathrm{P}(A' \cap B' \cap C') = \frac{1}{4} - p$. [4 marks]

Answer .....

(b) Find the range of possible values of p. [2 marks]

Answer .....

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(c) Find the value of p for which $\mathrm{P}(A \cap B \cap C) = \mathrm{P}(A)\,\mathrm{P}(B)\,\mathrm{P}(C)$, and find $\mathrm{P}(A \cup B \cup C)$ for this value. [2 marks]

Answer .....

Total for E1: 8 marks

Extension hints

Cover these with paper. Uncover one at a time.

E1

Hint 1 Each pair is independent, so $\mathrm{P}(A \cap B) = \mathrm{P}(A \cap C) = \mathrm{P}(B \cap C) = \frac{1}{4}$. Put p in the centre of a Venn diagram and work outwards.

Hint 2 $A \cap B$ only is $\frac{1}{4} - p$. Then A only is $\frac{1}{2}$ minus the three other regions of A. Every region must be at least 0.

Hint 3 For (c), the three events would be fully independent only if $\mathrm{P}(A \cap B \cap C) = \mathrm{P}(A)\,\mathrm{P}(B)\,\mathrm{P}(C)$.

How did it go?

Colour one circle on each line: not yet, nearly, yes.

I can write events in set notation and describe a shaded region of a Venn diagram.	○ ○ ○
I can find the probability of a set expression from a Venn diagram of counts or probabilities.	○ ○ ○
I can build a three-set Venn diagram from mutually exclusive and independent events.	○ ○ ○
I can find unknown probabilities from conditions written in set notation.	○ ○ ○

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