

# Spearman's Rank

Rank from Top to Bottom

Q1

At a village fair, ten jams, A–J, are given a score between 0 and 50 by two judges.

$$n = 10$$

The judges' scores are given in the table below.

	A	B	C	D	E	F	G	H	I	J
Judge 1	27	45	29	34	31	29	35	38	44	30
Judge 2	24	23	29	36	40	17	41	38	15	18
Judge 1 RANK	10	1	8.5	5	6	8.5	4	3	2	7
Judge 2 RANK	6	7	5	4	2	9	1	3	10	8
d	4	6	3.5	1	4	0.5	3	0	8	1
d <sup>2</sup>	16	36	12.25	1	16	0.25	9	0	64	1

$$\sum d^2 = 155.5$$

- (a) Calculate Spearman's rank correlation coefficient for the scores in the table.

Spearman's Rank Correlation Coefficient

$$r_s = 1 - \frac{6 \sum d^2}{n(n^2 - 1)}$$

$$= 1 - \frac{6 \times 155.5}{10 \times 99}$$

$$= 1 - \frac{311}{330} \quad \text{Answer } \frac{19}{330} \quad [5]$$

- (b) Give an interpretation, in context, of your answer to part (a).

There is no correlation between judges' rankings.

The judges do not agree with each other.

Correlation perfect negative  $-1$   $\xrightarrow{\text{no correlation}}$   $+1$  perfect positive

Jason suggests calculating the equation of a regression line to model the relationship between the judges' scores.

- (c) Explain why Jason's suggestion is not appropriate.

Since there is no correlation the points are NOT close to a line so a line is not suitable. [2]

A value of  $\frac{19}{330}$  shows points are very spread out like this

```

    x x x
    x x x
    
```

Gaby is researching the final position of a football team in the English Premier League and the mean value of all the players in the team.

- (a) Suggest a diagram that Gaby could draw to see if there is an association between the final position and the mean value.

Q2

Scattergraph

(1)

The table gives information about the data for the 2018–2019 season that Gaby used.

Team	Mean value of all players in the team (£ million)		Rank	$d$	$d^2$
	Value	Rank	Final position of the team		
Arsenal FC	14.13	6	5	1	1
AFC Bournemouth	4.67	15	14	1	1
Brighton	4.21	17	17	0	0
Burnley FC	5.63	13	15	-2	4
Cardiff City	2.17	20	18	2	4
Chelsea FC	19.38	5	3	2	4
Crystal Palace	7.29	10	12	-2	4
Everton FC	10.74	7	8	-1	1
Fulham FC	6.70	12	19	-7	49
Huddersfield Town	3.43	19	20	-1	1
Leicester City	8.66	8	9	-1	1
Liverpool FC	23.08	3	2	1	1
Manchester City	22.92	4	1	3	9
Manchester United	23.80	2	6	-4	16
Newcastle United	5.41	14	13	1	1
Southampton FC	6.76	11	16	5	25
Tottenham Hotspur	24.11	1	4	3	9
Watford FC	4.37	16	11	5	25
West Ham United	8.37	9	10	1	1
Wolverhampton	4.01	18	7	11	121

- (b) Calculate Spearman's rank correlation coefficient for the information in the table. You may complete the  $d$  column and  $d^2$  column of the table to help you.

$$\sum d^2 = 278$$

$$\text{Spearman's Rank} = 1 - \frac{6 \sum d^2}{n(n^2 - 1)}$$

$$1 - \frac{6 \times 278}{20 \times 399}$$

$$0.791 \quad (3)$$

- (c) Interpret your answer to part (b) in the context of Gaby's research. You should refer to the effects of any anomalous data.

There is a positive correlation between value of the team and the final position in table. This means the more valuable the players the higher the final position in the table

John and Jack each took part in some challenges at a Fun Day.

**Q3**

Each boy ranked the challenges in order of difficulty from 1 (easiest) to 8 (hardest).

Their results are given in the table below.

	A	B	C	D	E	F	G	H
John	2	1	4	8	5	3	7	6
Jack	5	2	6	1	7	4	3	8
$d$	3	1	2	7	2	1	4	2
$d^2$	9	1	4	49	4	1	16	4

- (a) Calculate Spearman's rank correlation coefficient for the data in the table.  $\sum d^2 = 88$

Give your answer correct to three decimal places.

$$\text{Spearman's Rank} = 1 - \frac{6 \sum d^2}{n(n^2 - 1)}$$

$$= 1 - \frac{6 \times 88}{8 \times 63}$$

$$= 1 - \frac{22}{21}$$

Answer \_\_\_\_\_ [4]

$$= -0.048$$

- (b) Give an interpretation of your answer to part (a).  
 For one of the challenges at the Fun Day, participants had to climb to the top of a rope as quickly as possible.
- No correlation  
 There is no agreement in Ranking between John & Jack.*

Anita thinks that taller people perform better at this challenge.

She records the height,  $x$  (cm), and time,  $y$  (seconds), for the first 10 participants and draws a scatter diagram of her results.

The equation of the line of best fit on Anita's scatter diagram is

$$y = 63 - 0.192x$$

- (d) Niall is 152 cm tall.

$$y = 63 - 0.192(152)$$

Use the equation of the line of best fit to estimate how long it might take for Niall to climb to the top of the rope.

$$y = 33.8$$

Ans 34

seconds

Amelia wants to see if there is a relationship between the height of a female athlete and the time it takes her to run 100 metres.

Q4

The table gives information collected by Amelia from the internet on the heights of 8 female athletes and the best time taken by each athlete to run 100 metres.

Athlete	Height (metres)	Time (seconds)	Height ranks	Time ranks	<i>d</i>	<i>d</i> <sup>2</sup>
A	1.79	<del>10.90</del>	1	5	4	16
B	1.75	<del>10.83</del>	2	2	0	0
C	1.68	<del>10.94</del>	3	7	4	16
D	1.67	<del>10.71</del>	4	1	3	9
E	1.65	<del>11.80</del>	5	8	3	9
F	1.60	<del>10.92</del>	6	6	0	0
G	1.59	<del>10.87</del>	7	4	3	9
H	1.52	<del>10.86</del>	8	3	5	25

*difference*

*n=8*

(Source: [www.olympic.org](http://www.olympic.org))

$\sum d^2 = 84$

Amelia's hypothesis is that the taller the female athlete, the less time it takes her to run 100 metres.

- (a) Is Amelia's hypothesis supported by the data?  
You must justify your answer.

Find Spearman's Rank

$$1 - \frac{6 \sum d^2}{n(n^2 - 1)}$$

$$1 - \frac{6 \times 84}{8 \times 63}$$

$$= 1 - 1$$

$$= 0$$

There is no correlation between heights and times.

**Context Answer**

It seems as though the height of the athlete has no impact on the time it takes for the athlete to run 100m

Friends Emma and Ronan are tasting different types of cake to serve at their wedding.

**Q5**

They taste eight types of cake and give each one a score out of 20

Their scores are given in the table below.

Type of cake	A	B	C	D	E	F	G	H
Emma's score	12	19	7	10	13	15	5	8
Ronan's score	14	17	10	12	18	15	7	10

Emma's Rank    4   1   7   5   3   2   8   6

Ronan's Rank    4   2   6.5   5   1   3   8   6.5

$d = \text{difference}$     0   1   0.5   0   2   1   0   0.5

$d^2$     0   1   0.25   0   4   1   0   0.25

$$\sum d^2 = 6.5$$

- (a) Calculate Spearman's rank correlation coefficient for the data in the table. *formula given to you in formula page*

$$1 - \frac{6 \sum d^2}{n(n^2-1)} = 1 - \frac{6 \times 6.5}{8 \times 63} = 1 - \frac{13}{168} = \frac{155}{168} = 0.923$$

- (b) How could Emma and Ronan interpret this value?

There is strong agreement between the scores. Emma and Ronan think similarly about which cakes are the best and which are the worst. [2]

- (c) Give two reasons why calculating Spearman's rank correlation coefficient is appropriate for the type of data in the table.

- Because cakes are scored by 2 judges and results are in pairs [1]
- Easy to rank the judges scores. [1]