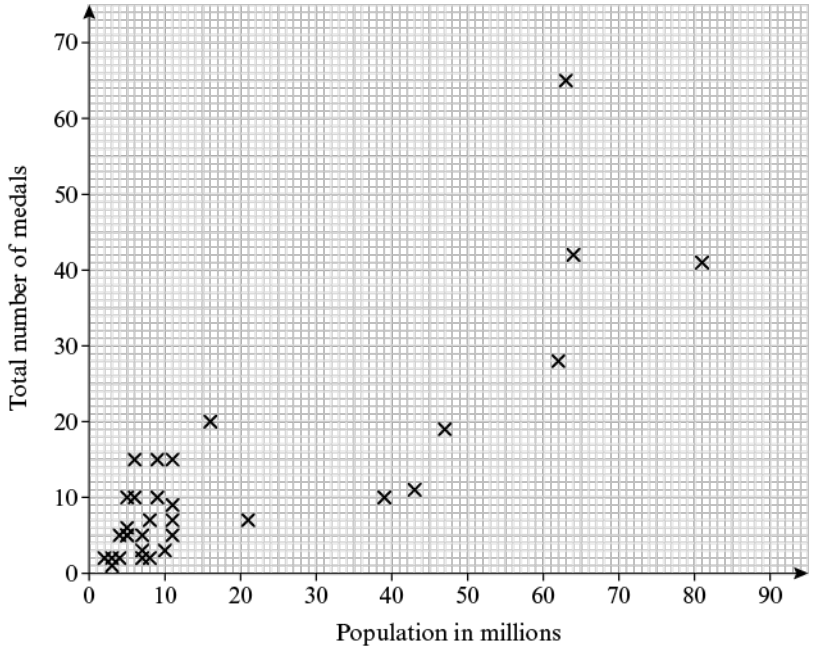
1 Figure 1 shows the population in millions, p, and the total number of medals won, m, for the European countries that won medals at an athletics tournament.

Figure 1



a Describe the correlation between p and m. **(1 mark)**

b Find the value of the product moment correlation coefficient between p and m.

You may use $S_{pp} = 15004$, $S_{mm} = 6110$ and $S_{pm} = 7968$ **(2 marks)**

c Interpret the correlation between p and m in context. **(1 mark)**

d Many European countries did not win any medals in the tournament.

Describe the effect this would have on the correlation coefficient found in part **b** if these were included in the data. **(1 mark)**

e China has a population of approximately 1.4 billion.

Apart from China not being in Europe, give a reason why the correlation found in part **b** may not apply to China. **(1 mark)**

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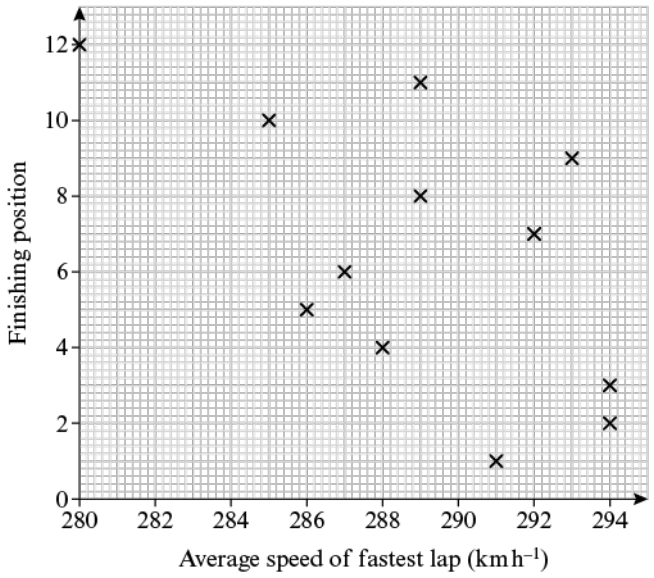
2 Figure 2 shows the finishing position, *y,* against the average speed of the fastest lap, *x* in km h^{-1}, for a randomly chosen motorcycle race which was held over eight laps with 12 competitors.

Figure 2



a Find the value of the product moment correlation coefficient between the finishing position and average speed of the fastest lap. **(2 marks)**

You may use $S_{xx} = 190.00$, $S_{yy} = 143$ and $S_{xy} = -95$

b Interpret the correlation between the finishing position and the average speed of the fastest lap in context. **(1 mark)**

c Stating your hypotheses clearly, test whether or not there is a negative correlation between finishing position and average speed of fastest lap.

Use a 5% level of significance. **(4 marks)**

3 The quality manager of a food-producing factory wants to investigate if there is a correlation between the area of the top of a certain brand of cake, *a*, measured in mm^2, and the quality measure, *q,* measured on a scale between 0 and 1.

The quality manager selects a random sample of 30 cakes and records the area and quality measure for each cake. They calculated,

$$\Sigma q = 7.953\ ,\ \Sigma q^2 = 2.796\ ,\ S_{aa} = 2\ 202\ 699,\ S_{aq} = 11.2247$$

a Calculate the product moment correlation coefficient between *a* and *q*. **(4 marks)**

b Based on the correlation coefficient in part **a**, explain why we cannot assume there is no relationship between *a* and *q*. **(1 mark)**

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4 A summer school ranked their courses based on the number of students enrolled, with the course with the most students enrolled given rank 1.

Table 1 shows the student satisfaction score for the ten most popular courses.

Student satisfaction is a score from 1to 5, where 5 is most satisfied.

Table 1

Rank, *p*	1	2	3	4	5	6	7	8	9	10
Student satisfaction, *q*	4.32	4.19	4.25	4.15	4.4	4.2	4.09	4.13	3.95	4.1

a Calculate Spearman's rank correlation coefficient for p and q. **(4 marks)**

b Describe the correlation between p and q and interpret this in context. **(2 marks)**

c Explain why it would not be sensible to assume that this correlation applies to all courses run by the summer school. **(1 mark)**

d Without re-calculating the correlation coefficient, state if the Spearman's rank correlation coefficient would change if the student satisfaction for the course ranked third was 4.28 instead of 4.25. Explain your answer. **(1 mark)**

5 A researcher is investigating if lighter mountain bikes are more expensive.

A random sample of 12 different models of mountain bikes for sale in America was selected.

The mass, m, in lbs, and price when new, p, in US dollars, of each model of bike was recorded.

The conversion $x = \frac{m}{2.2}$ was used to convert the mass from lbs to kg.

The conversion $y = 0.74p$ was used to convert the price from US dollars to UK pounds.

The following results were obtained,

$$\Sigma x = 171.36,\ \Sigma x^2 = 2645.08,\ S_{xx} = 17.96$$
$$S_{yy} = 702114,\ S_{xy} = 702114$$

a Find the value of the product moment correlation coefficient between x and y. **(2 marks)**

b Work out the value of S_{ww}. **(2 marks)**

c Write down the value of the product moment correlation coefficient between m and p. **(1 mark)**

d State two limitations of this analysis. **(2 marks)**

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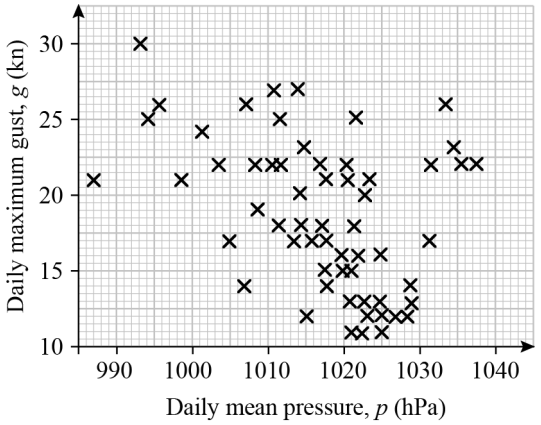
6 The speed and direction of wind and wind gusts affect the safety of aircraft taking off and landing.

A meteorologist collected data on the daily maximum gust, g in kn, and daily mean pressure, p in hPa, at an airport in London for the 61 days during September and October 2015.

She coded the data using $x = 1.15g$ to convert the daily maximum gust into miles per hour.

The raw data and part of the analyses were corrupted by a computer virus. Only a scatter diagram (Figure 3) and some summary statistics survived.

Figure 3



$S_{pp} = 5268 \quad \Sigma x = 1300 \quad \Sigma x^2 = 29\,516 \quad S_{px} = -1320$

where,

p is the daily mean pressure in hectopascals (hPa)

g is daily maximum gusts in knots (kn)

x is daily maximum gusts in miles per hour.

The coding $x = 1.15g$ was used as 1 knot = 1.15 miles per hour.

a Find the value of the product moment correlation coefficient between p and x. **(4 marks)**

b Write down the value of the product moment correlation coefficient between p and x. **(1 mark)**

The pressure reading on a certain day at the airport in September is 1032 hPa.

c Comment on whether you would expect the day to be windy, giving a reason, based on Figure 3 and your answer to part **b**. **(2 marks)**

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7 A consumer website gave percentage ratings to a random sample of 10 washing machines based on a quality system, to see if there is a correlation between the quality and cost of the washing machines.

The quality system took into account ease of use, design, performance, and instructions.

Table 2

Rating (%)	69	87	54	73	95	49	66	55	74	67
Cost (£)	550	1699	220	700	2000	519	348	800	1049	550

a Show that the Spearman's rank correlation coefficient for this data is 0.827. **(5 marks)**

b Stating your hypotheses clearly, test whether this data supports the claim that there is a correlation between the rating and the cost of washing machines, at a 5% significance level. **(4 marks)**

c State one limitation of this analysis. **(1 marks)**

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