Advanced Business Mathematics

SAMPLE TIME CONSTRAINED ASSESSMENT
MARKING SCHEME

This marking scheme has been prepared as a **guide only** to markers. This is not a set of model answers, or the exclusive answers to the questions, and there will frequently be alternative responses which will provide a valid answer. Markers are advised that, unless a question specifies that an answer be provided in a particular form, then an answer that is correct (factually or in practical terms) **must** be given the available marks.

If there is doubt as to the correctness of an answer, the relevant NCC Education materials should be the first authority.

Throughout the marking, please credit any valid alternative point.

Where markers award half marks in any part of a question, they should ensure that the total mark recorded for the question is rounded up to a whole mark.

Section A
You must answer this question

Marks

Question 1

a) The data below shows the annual *per capita* (per person) consumption of three items over a two-year period.

	2019		2020	
	Price $	**Quantity (kg)**	**Price ($)**	**Quantity (kg)**
Item 1	8.26	15 520	9.10	16 100
Item 2	3.85	9520	3.95	9420
Item 3	12.58	7850	13.15	8150

Using **2019** as the base year calculate:

i) the *Laspeyres price index* for 2020. Give your answer to TWO (2) decimal places. **3**

Mark scheme

$$LPI = \frac{\Sigma q_1 p_2}{\Sigma q_1 p_1} \times 100$$

$$= \frac{(15520 \times 9.10) + (9520 \times 3.95) + (7850 \times 13.15)}{(15520 \times 8.26) + (9520 \times 3.85) + (7850 \times 12.58)} \times 100$$

$$= \frac{282063.5}{263600.2} \times 100$$

$$= 107.00 \textit{ (to 2 d.p)}$$

(1 mark for partially correct working, 2 marks for wholly correct working. 1 mark for correct answer.)

ii) the Paasche price index for 2019. Give your answer to TWO (2) decimal places. **3**

Mark scheme

$$PPI = \frac{\Sigma q_2 p_2}{\Sigma q_2 p_1} \times 100$$

$$= \frac{(16100 \times 9.10) + (9420 \times 3.95) + (8150 \times 13.15)}{(16100 \times 8.26) + (9420 \times 3.85) + (8150 \times 12.58)} \times 100$$

$$= \frac{290891.5}{271780} \times 100$$

$$= 107.03 \quad \textit{(to 2 d.p)}$$

(1 mark for partially correct working, 2 marks for wholly correct working. 1 mark for correct answer.)

Marks

b) For the equation: **3**

$$y = 5x^2\, ln(2x)$$

Differentiate y with respect to x.

Mark scheme

Using the product rule: $\frac{d}{dx}\left(f(x)g(x)\right) = f(x)\frac{dg}{dx} + g(x)\frac{df}{dx}$

$$\frac{dy}{dx} = 5x^2 \times \frac{1}{x} + 10x\, ln(2x)$$
$$= 5x + 10x\, ln(2x)$$

(Award 1 mark for using product rule and 1 mark for each correct term.)

c) Calculate the *Pearson Correlation Coefficient* for the set of sample observations given in the table below. **7**

x	25	31	37	39	42	46
y	89	71	79	68	67	52

Mark scheme

Using:

$$R = r = \frac{n\Sigma x_i y_i - \Sigma x_i \Sigma y_i}{\sqrt{\left(n\Sigma x_i^2 - (\Sigma x_i)^2\right)(n\Sigma y_i^2 - (\Sigma y_i)^2}}$$

x	y	xy	x^2	y^2
25	***89***	***2225***	***625***	***7921***
31	***71***	***2201***	***961***	***5041***
37	***79***	***2923***	***1369***	***6241***
39	***68***	***2652***	***1521***	***4624***
42	***67***	***2814***	***1764***	***4489***
46	***52***	***2392***	***2116***	***2704***
$\Sigma x = 220$	$\Sigma y = 426$	$\Sigma xy = 15207$	$\Sigma x^2 = 8356$	$\Sigma y^2 = 31020$

$$r = \frac{6(15207) - 220(426)}{\sqrt{(6(8356) - 220^2\,) \times (6(31020) - 426^2)}}$$

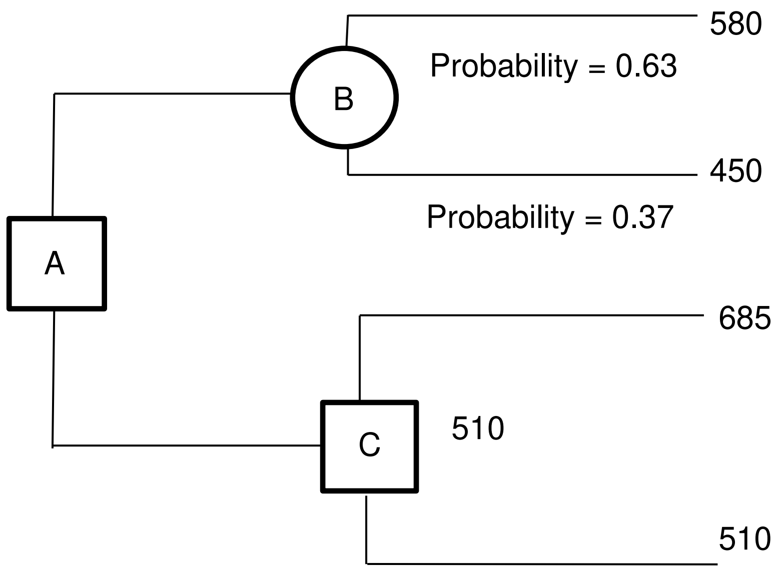
$$= -\frac{2478}{\sqrt{8061984}} = -0.873$$ ***(to 3 sig fig.)***

So, the Pearson Correlation Coefficient is -0.873 (to 3 sig fig)

- ***Award 1 mark for*** Σx
- ***Award 1 mark for*** Σy
- ***Award 1 mark for*** Σxy
- ***Award 1 mark for*** Σx^2
- ***Award 1 mark for*** Σy^2
- ***Award 1 mark for correct workings in calculation of*** r ***and 1 mark for correct value of r.***

Marks

d) The following *decision tree* has been created by a management team.



i) Roll back the decision tree **and** find the values at nodes A **and** B. In finding the value for node A you will need to decide how the *optimisation rule* is being used. **4**

Mark scheme

Node B is an event or chance node, so is calculated using expected value. Value at node B = 0.63(580) + 0.37(450)
= 531.9
(1 mark for correct workings. 1 mark for numerically correct answer.)

Node A is a decision mode and is valued by an optimum choice. Since node C has been valued at 510, the optimisation rule is being used to select the minimum value. Value at node A = min [531.9, 510] = 510

(1 mark for recognising that the optimisation rule is being used to select the minimum value.
1 mark for calculating value at Node A)

Total 20 Marks

Section B
Answer any FOUR (4) questions from this section

Marks

Question 2

A bakery produces two flavours of cake – A and B. The available demand is known for the following week.

Cake	Demand (no of cakes)
A	42
B	29

The company must also supply a minimum of 15 type A cakes for an existing contract with a regular customer.

The production of the cakes requires two manufacturing processes: the mixing phase and the baking phase. There are no input supply constraints.

The mixing phase has 210 hours available each month, and the baking phase has 350 hours available each month. The manufacturing times and profit for each type of table are given below:

	A	B
Mixing phase (time per cake)	15 minutes	12 minutes
Baking phase (time per cake)	50 minutes	35 minutes
Profit per cake	£3.50	£4.10

Marks

a) The company wishes to plan for the production of cakes for the following week with the intention of **maximising** profit. Formulate the problem as an objective function and associated set of inequalities. **You are not required to obtain a numerical solution to the problem.** **9**

Mark scheme

Let A and B denote the weekly number of the two types of cake
Maximise: 3.5A + 4.1B
(Award <u>2 marks</u>. If incorrect answer, caused by minor error award 1 mark.)

Subject to:
Cake A demand: A ≤ 42
Cake B demand: B ≤ 29
Contract for cake A: A ≥ 15

(Award 1 mark for one simple constraint, award <u>2 marks</u> for all three simple constraints.)

Mixing phase: $\frac{15A}{60} + \frac{12B}{60} \leq 210$ ***(may be simplified)***

(1 mark partially correct, 2 marks correct inequality)

Baking phase: $\frac{50A}{60} + \frac{35B}{60} \leq 350$ ***(may be simplified)***

(1 mark partially correct, 2 marks correct inequality)

Non-negativity: B ≥ 0
(Award <u>1 mark</u> for inequality. If incorrect due to minor error award 0.5 marks.)

b) The bakery decides to produce two more types of cake, C and D.

In order to plan for production next week with the intention of maximising profits, they formulate the problem as an objective function. They then use the Excel solver routine to solve the problem.

i) According to the 'Answer' report, the time available for baking is a *binding constraint*. Explain what this means. **2**

Mark scheme

The optimal solution is constrained by the time available for baking (1 mark). If the time available for baking was changed, the optimal solution would change (1 mark).

Marks

ii) According to the 'Sensitivity' report, the shadow price of the mixing time is zero. Explain why this is the case. **2**

Mark scheme

The shadow price of the <u>mixing time</u> is zero because at the optimal solution, not all of the time has been used up (1 mark).
If it had been beneficial to use more time for <u>mixing</u> the optimal solution would have done so (1 mark).

iii) The 'Sensitivity' report shows that the baking time for the cakes has a shadow price of £5.60. Explain what this means. **2**

Mark scheme

This means that the total profit would increase by £5.60 if one more unit of baking time was made available (1 mark) and the amount of all other resources remained the same (1 mark).

c) The bakery uses two ovens to bake the cakes, oven A and oven B.

Oven A bakes 45% of the cakes and oven B bakes 55% of the cakes.

The probability that oven A undercooks a cake is 0.02
The probability that oven B undercooks a cake is 0.03

i) A cake is chosen at random. Calculate the probability that it will be undercooked. **2**

Mark scheme

First, define the notation for the event.

Let A be the event that the cake was baked in oven A.
Let B be the event that the cake was baked in oven B.
Let U be the event that the cake was undercooked.

Using the theorem of total probability:

$$\begin{aligned} P(U) &= P(U|A)P(A) + P(U|B)P(B) \\ &= (0.02 \times 0.45) + (0.03 \times 0.55) \\ &= 0.0255 \end{aligned}$$

1 mark for correct workings for calculation of P(U) and 1 mark for correct value of P(U).

Marks

ii) Given that a cake selected at random is undercooked, find the probability that the cake was baked in oven B (showing your workings). **3**

Mark scheme

From the theorem of Bayes:

$$\boldsymbol{P(B|U) = \frac{P(U|B)P(B)}{P(U)}}$$

$$= \frac{\mathbf{0.03 \times 0.55}}{\mathbf{0.0255}}$$

$$= \mathbf{0.647} \textit{ (to 3 sf)}$$

Award 1 mark for partially correct method and 2 marks for wholly correct method for calculation of $P(B|U)$ and 1 mark for correct value of $P(B|U)$.

Total 20 Marks

Question 3

a) A factory, which produces rice, records the amount of rice in 10 bags as follows:

500g 498g 502g 507g 483g 495g 491g 493g 496g 501g

i) Calculate the *range* of the amount of rice in these 10 bags. **1**

Mark scheme

Range of amount of rice: 507g – 483g = 24g (1 mark)

ii) Calculate the *median* amount of rice in these 10 bags. **1**

Mark scheme

Median amount of rice: $\frac{\mathbf{496+498}}{\mathbf{2}}\mathbf{g} = \mathbf{497g}$ ***(1 mark)***

iii) Calculate the *mean* amount of rice in these 10 bags. Show your workings. **1**

Mark scheme

The mean is:

$$\bar{x} = \frac{500 + 498 + 502 + 507 + 483 + 495 + 491 + 493 + 496 + 501}{10}$$

$$= 496.6\ g$$

(1 mark)

Marks

iv) Calculate the *sample variance* **and** *sample standard deviation* of the amount of rice in these 10 bags. **5**

Mark scheme

Sample variance: $s^2 = \frac{\sum(x-\bar{x})}{n-1}$

x	$x-\bar{x}$	$(x-\bar{x})^2$
500	***3.4***	***11.56***
498	***1.4***	***1.96***
502	***5.4***	***29.16***
507	***10.4***	***108.16***
483	***-13.6***	***184.96***
495	***-1.6***	***2.56***
491	***-5.6***	***31.36***
493	***-3.6***	***12.96***
496	***-0.6***	***0.36***
501	***4.4***	***19.36***
TOTAL		***402.4***

Award 1 mark for mean differences.
1 mark for mean square differences.
1 mark for sums.

$s^2 = 402.4/9$
$= 44.7$ ***(to 3 sig fig.)***

1 mark for correct variance.

Standard deviation:

$s = +\sqrt{402.4/9} =$

$= 6.69$ ***(to 3 sig fig)***

Award 1 mark for correct standard deviation.

Marks

b) The mean amount of rice in a bag is supposed to be 500g, but the factory suspects that a machine is underfilling the bags. Determine whether there is evidence to support this at the 5% significance level. You need to state the null **and** alternative hypothesis, the critical value of the test statistic **and** your conclusions. You should assume a normal distribution. Show your workings. **8**

Mark scheme

Null hypothesis, H0:
The mean average amount of rice in the bags is 500g

H0: $\mu = 500$
(1 mark)

Alternative hypothesis, H1:
The mean average amount of rice in the bags is less than 500g

H1: $\mu < 500$
(1 mark)

The critical value of the test statistic is
$t_{0.05}(n - 1) = t_{0.05}(9) = -1.83$ ***(to 3 sig fig)***
That is, if T < - 1.83 then H0 is rejected in favour of H1.

(Award 2 marks for correct numerical answer.
Award 1 mark for correct working but error in either calculating degrees of freedom or reading value from table.)

The test statistic is:

$$T = \frac{\bar{x}-\mu}{s/\sqrt{n}}$$

$$= \frac{496.6-500}{6.69/\sqrt{10}}$$

$= -1.61$ ***(to 3 sig fig)***
(2 marks.)

(Award 2 marks for numerically correct answer, 1 mark for numerically incorrect answers due to minor errors)

The test statistic is greater than the critical value, -1.61 > -1.83. At the 5% significance level there is insufficient evidence to reject the null hypothesis. So, at the 5% significance level, there is not enough evidence to support the alternative hypothesis that the mean average amount of rice in the bags is less than 500g. (2 marks)

(If student has made errors in calculating the test statistic but rejects/ accepts either H0 or H1 correctly based on that statistic award full 2 marks here. Only penalise students once for errors in the calculation where the actual error is made.)

Marks

c) Explain what is meant by a *Type 1 error* **and** how the chance of this type of error can be minimised. **2**

Mark scheme

A Type 1 error occurs when the null hypothesis is incorrectly rejected. (1 mark)
The chance of a Type 1 error occurring can be minimised by lowering the significance level (α). (1 mark)

d) Explain what is meant by a *Type 2 error* **and** how the chance of this type of error can be minimised. **2**

Mark scheme

A Type 2 error occurs when the null hypothesis is incorrectly accepted. (1 mark).
The chance of a Type 2 error occurring can be minimised by increasing sample size. (1 mark)

Total 20 Marks

Question 4

a) A bookshop has recorded their book sales volume in hundreds (00s) over a FOUR (4) year period. The data is shown in the table below. **20**

i) Complete the analysis below using an *additive decomposition model* and *CMA 4*. With the aid of sketch graphs, comment upon the seasonality and trend.

Year	Quarter	Y Sales volume (00s)	T (CMA 4)
2017	Q1	78	
	Q2	69	
	Q3	75	76.625
	Q4	83	77.625
2018	Q1	81	78.75
	Q2	74	79.625
	Q3	79	80.375
	Q4	86	81.375
2019	Q1	84	82.5
	Q2	79	83.625
	Q3	83	
	Q4	91	
2020	Q1	89	
	Q2	82	
	Q3	85	
	Q4	96	

Mark scheme

Year	Quarter	Y Sales volume (00s)	T (CMA 4)	***Y-T***	***S***	***S + T***
2017	Q1	78				
	Q2	69				
	Q3	75	76.625	***-1.625***	***-1.625***	***75***
	Q4	83	77.625	***5.375***	***5.042***	***82.667***
2018	Q1	81	78.75	***2.25***	***2.083***	***80.833***
	Q2	74	79.625	***-5.625***	***-5.208***	***74.417***
	Q3	79	80.375	***-1.375***	***-1.625***	***78.75***
	Q4	86	81.375	***4.625***	***5.042***	***86.417***
2019	Q1	84	82.5	***1.5***	***2.083***	***84.583***
	Q2	79	83.625	***-4.625***	***-5.208***	***78.417***
	Q3	83	***84.875***	***-1.875***	***-1.625***	***83.25***
	Q4	91	***85.875***	***5.125***	***5.042***	***90.917***
2020	Q1	89	***86.5***	***2.5***	***2.083***	***88.583***
	Q2	82	***87.375***	***-5.375***	***-5.208***	***82.167***
	Q3	85				
	Q4	96				

Continue CMA 4 calculations for final 4 values.

Possible workings:

$$\boldsymbol{T\ (2019\ Q3) = \frac{1}{8}\ (84 + 2(79) + 2(83) + 2(91) + 89)}$$

$$\boldsymbol{= 84.875}$$

$$\boldsymbol{T\ (2019\ Q4) = \frac{1}{8}\ (79 + 2(83) + 2(91) + 2(89) + 82)}$$

$$\boldsymbol{= 85.875}$$

$$\boldsymbol{T\ (2020\ Q1) = \frac{1}{8}\ (83 + 2(91) + 2(89) + 2(82) + 85)}$$

$$\boldsymbol{= 86.5}$$

$$\boldsymbol{T\ (2020\ Q2) = \frac{1}{8}\ (91 + 2(89) + 2(82) + 2(85) + 96)}$$

$$\boldsymbol{= 87.375}$$

(Award 1 mark for each correct CMA 4 calculation. <u>Total of 4 marks</u> available)

Calculate column of $Y - T$ values, for example:

75 - 76.625 = -1.625
(For Y - T calculations marks <u>award up to 3 marks</u>. For errors deduct 1 mark up to a maximum of 3 marks. If error due to incorrect value of T or S but calculation correct do not deduct marks here.)

Marks

Possible workings for calculation of columns of S values.

$$s_3 = \frac{(-1.625)+(-1.375)+(-1.875)}{3} = -\mathbf{1.625}$$

$$s_4 = \frac{5.375+4.625+5.125}{3} = \mathbf{5.042} \textit{ (to 3 dp)}$$

$$s_1 = \frac{2.25+1.5+2.5}{3} = \mathbf{2.083} \textit{ (to 3 dp)}$$

$$s_2 = \frac{(-5.625)+(-4.625)+(-5.375)}{3} = -\mathbf{5.208} \textit{ (to 3 dp)}$$

For S calculations award 1 mark per correct calculation up to a <u>maximum of 4 marks</u>. If error due to incorrect values of Y - T but calculation correct do not deduct marks here.

Award an <u>additional 2 marks</u> for all values entered into correct places in table. Deduct 1 mark per error up to a maximum of 2 marks.

Calculate columns of S + T values, for example:

$$\mathbf{76.625 + (-1.625) = 75}$$

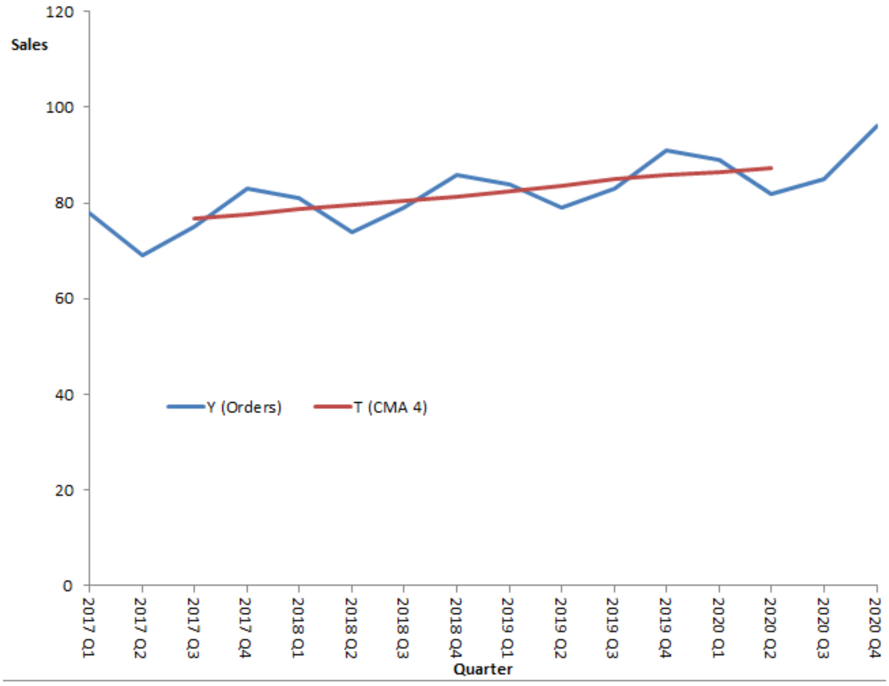
N.B. Values in S +T column of table have been rounded to 3 decimal places where necessary.

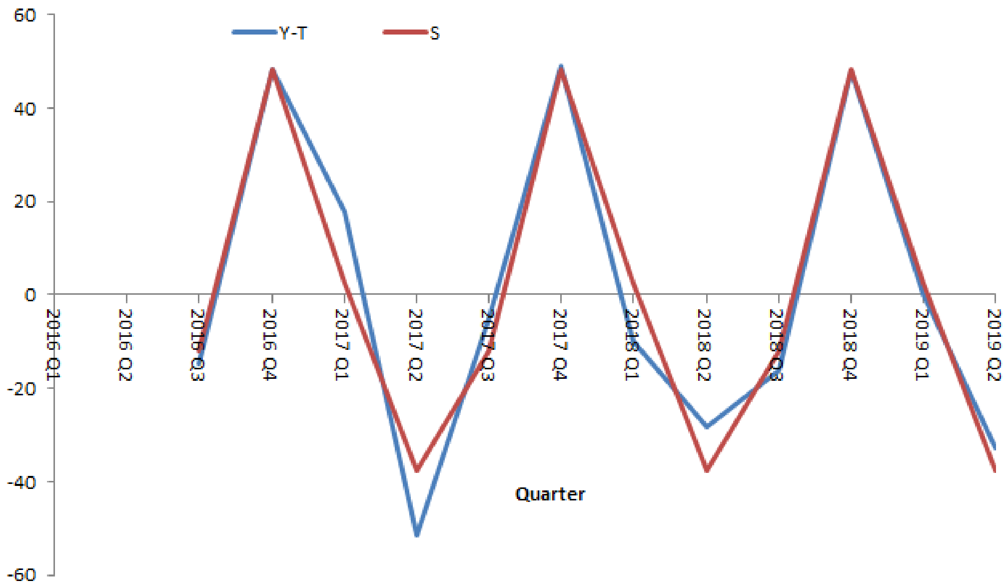
(For S + T calculations <u>award up to 3 marks.</u> For errors deduct 1 mark up to a maximum of 3 marks. If error due to incorrect value of T or S but calculation correct do not deduct marks here.)

<u>Award up to 2 marks</u> for valid observations. For example:
Analysis appears to show an upwards trend in orders (1 mark)
There appears to be a high season in Q4 and a low season in Q2 (1 mark)

<u>Award up to 2 marks</u> for a sketch of a graph. Sketches of possible graphs are shown below. The graphs are sketches so do not need to be accurate, however they do need to show main features. Award 1 mark for each curve on the graph.

Marks





Total 20 Marks

Marks

Question 5

a) A company has developed a model for its demand curve:

$$P(q) = 58900 - 310q$$

Where $P(q)$ denotes the unit price in GBP (£) and q the quantity of items manufactured **and** sold.

i) Find an expression for *total revenue*, $R(q)$. Show your workings. **2**

Mark scheme

Total revenue $\boldsymbol{R(q)}$ ***is given by:***

$$\boldsymbol{R(q) = q \times P(q)}$$
$$\boldsymbol{= 58\,900q - 310q^2}$$

1 mark for correct method, 1 mark for correct answer.

ii) Differentiate the expression for the total revenue, $R(q)$, to find the gradient of $R(q)$. Show your workings. **2**

Mark scheme

$$\boldsymbol{R'(q) = 58\,900 - 620q}$$

1 mark for each correctly differentiated element.

iii) Find the coordinates of the turning point of $R(q)$. Show your workings. **4**

Mark scheme

The turning point occurs where $\boldsymbol{R'(q) = 0}$
i.e. where $\boldsymbol{58\,900 - 620q = 0}$ ***(1 mark)***
Hence $\boldsymbol{q = 95}$ ***(1 mark)***

When $\boldsymbol{q = 95}$
$\boldsymbol{R(q) = (58\,900 \times 95) - 310(95)^2 = £2\,797\,750}$ ***(1 mark)***

Hence the turning point occurs at (95, 2 797 750) (1 mark)

Marks

iv) Sketch a graph of total revenue against output. You should label the axes **and** the turning point. State the maximum total revenue. **4**

Mark scheme

Coordinates of turning point (95, 2 797 750)

Award 1 mark for a graph showing a maximum turning point and 1 mark for correctly labelled axes.

Award 1 mark for correctly labelled turning point.

Hence, the maximum revenue is £2 797 750. (1 mark)

b) 12 learner drivers are sitting their driving test. The probability of passing the driving test is 0.7. Calculate the probability that **at least** 10 of the learner drivers will pass the test. **4**

Mark scheme

Using the binomial distribution (1 mark for using binomial distribution)

$$P(X = x) = \frac{n!}{x!\,(n-x)!}p^x(1-p)^{(n-x)}$$

$$n = 12$$
$$p = 0.7$$

$$P(X = 10) + P(X = 11) + P(X = 12)$$
$$= \frac{12!}{10!\,(2)!}(0.7)^{10}(0.3)^2 + \frac{12!}{11!\,(1)!}(0.7)^{11}(0.3)^1 + \frac{12!}{12!\,(0)!}(0.7)^{12}(0.3)^0$$

(1 mark for partially correct method, 2 marks for wholly correct method)
$= 0.253$ ***(to 3 sig fig)***

(1 mark for correct answer)

Marks

c) A clothing manufacturer forecasts next season's demand for a coat as: expected demand 1450 and a standard deviation 300. Assume demand is normally distributed. Calculate the probability that the actual demand will be between 1330 and 1585. **4**

Mark scheme

***Calculate** z **– score,** $z = (x - \mu) / \sigma$*

$$= \frac{1330 - 1450}{300}$$

$$= -0.4$$

(Award 1 mark for numerically correct score)

***Calculate** z **– score,** $z = (x - \mu) / \sigma$*

$$= \frac{1585 - 1450}{300}$$

$$= 0.45$$

(Award 1 mark for numerically correct score.)

Use tables $P(-0.4 < z < 0.45) = 0.6736 - 0.3446$

$$= 0.329$$

(Award 1 mark for correct method and 1 mark for correct answer. If numerically incorrect answer due to errors in calculating z scores award 2 marks as FT.)

Total 20 Marks

Question 6

a) Six candidates are interviewed for a job. The two interviewers rank the candidates as follows:

Candidate	A	B	C	D	E	F
Interviewer 1	5	1	2	4	6	3
Interviewer 2	6	3	1	2	5	4

i) Calculate the *Spearman Correlation Coefficient*. Show your workings. **5**

Mark scheme

Using

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

Candidate	***A***	***B***	***C***	***D***	***E***	***F***
Interviewer 1	***5***	***1***	***2***	***4***	***6***	***3***
Interviewer 2	***6***	***3***	***1***	***2***	***5***	***4***
d	***-1***	***-2***	***1***	***2***	***1***	***-1***
d^2	***1***	***4***	***1***	***4***	***1***	***1***

$r_s = 1 - \frac{6\times12}{6\times35} \quad = 1 - \frac{72}{210} \quad = 0.657$ ***(to 3 sig fig.)***

1 mark for d values
1 mark for d² values
1 mark for sum
1 mark for use of formula
1 mark for correct answer

ii) Comment on the value of the *Spearman Correlation Coefficient.* **2**

Mark scheme

The Spearman Rank Correlation Coefficient indicates quite a strong positive relationship between the ranks assigned to the candidates by the two interviewers.

(Award 1 mark for positive and 1 mark for 'quite strong' or similar)

Marks

b) A survey is carried out in a large city. 686 people out of a random sample of 980 said that they had shopped online in the past month. Determine a 99% confidence interval for the proportion of people in the city that have shopped online in the past month. **6**

Mark scheme

Proportion = 686/980 = 0.7 (1 mark)
np ***and*** $n\,(1-p)$ ***are both greater than 5 so large sample CI for proportion can be used (1 mark).***

From tables $z_{99\%}$ ***= 2.5758 (1 mark)***

$$(p^-, p^+) = \left(\overline{p} - Z_\gamma\sqrt{\frac{\overline{p}(1-\overline{p})}{n}}, \overline{p} + Z_\gamma\sqrt{\frac{\overline{p}(1-\overline{p})}{n}}\right)$$

$$= \left(0.7 - 2.5758\sqrt{\frac{0.7\times0.3}{980}}, \quad 0.7 + 2.5758\sqrt{\frac{0.7\times0.3}{980}}\right)$$

$$= (0.662,\ 0.738)$$ ***(to 3 sig fig)***

Award 1 mark for workings.
Award 1 mark for correct value.
(If value incorrect due to incorrect calculation of either p or $z_{99\%}$ ***award 2 marks as FT)***

With 99% confidence, between 66.2% and 73.8% of the people in the city have shopped online in the past month.

(1 mark. If percentages incorrect due to incorrect calculations of (p^-, p^+) ***but interpretation correct award 1 mark.)***

Marks

c) A price index initially used 2015 as its base year. In 2019 the base year was updated.

YEAR	PRICE INDEX (2015 BASE)	PRICE INDEX (2019 BASE)
2015	100	
2016	101.8	
2017	102.7	
2018	104.9	
2019	106.3	100
2020		101.2

i) Link the two series to create a single series with 2019 as the base year. Give your answers to ONE (1) decimal place. **5**

Mark scheme

YEAR	PRICE INDEX (2015 BASE)	PRICE INDEX (2019 BASE)
2015	100	***94.1***
2016	101.8	***95.8***
2017	102.7	***96.6***
2018	104.9	***98.7***
2019	106.3	100
2020		101.2

Possible workings:

2015: $\mathbf{100} \times \frac{\mathbf{100}}{\mathbf{106.3}} = \mathbf{94.1}$ ***(to 1 d.p)***

2016: $\mathbf{101.8} \times \frac{\mathbf{100}}{\mathbf{106.3}} = \mathbf{95.8}$ ***(to 1 d.p)***

2017: $\mathbf{102.7} \times \frac{\mathbf{100}}{\mathbf{106.3}} = \mathbf{96.6}$ ***(to 1 d.p)***

2018: $\mathbf{104.9} \times \frac{\mathbf{100}}{\mathbf{106.3}} = \mathbf{98.7}$ ***(to 1 d.p)***

Award 1 mark for correct method.
Award 1 mark for each numerically correct answer.

Maximum of 5 marks.

ii) Use the single series to calculate the percentage change from 2017 to 2020 Give your answer to ONE (1) decimal place. **2**

Mark scheme

Percentage change from 2017 to 2020 $= \mathbf{100} \times \frac{\mathbf{101.2 - 96.6}}{\mathbf{96.6}} = \mathbf{4.8}\,\%$ ***(to 1 d.p.)***
(Award 1 mark for correct working. Award 1 mark for numerically answer.)

Total 20 Marks

End of paper

Formula sheet
Management statistics

Population mean and standard deviation

$$\mu = \frac{\sum f_i x_i}{N} \qquad \mu = \sum p_i x_i$$

$$\sigma = \sqrt{\frac{\sum f_i (x_i - \mu)^2}{N}} \qquad \sigma = \sqrt{\sum p_i (x_i - \mu)^2}$$

Population Coefficient of Variation

$$CV = \frac{\sigma}{\mu}$$

Sample mean, standard deviation and sample variance

$$\bar{x} = \frac{\sum f_i x_i}{n} \qquad s = \sqrt{\frac{\sum f_i (x_i - \bar{x})^2}{n-1}} \qquad \boldsymbol{s^2 = \frac{\Sigma (x - \bar{x})^2}{n-1}}$$

Sample skewness

$$\frac{n}{(n-1)(n-2)} \sum_{i=1}^{n} \left(\frac{x_i - \bar{x}}{s} \right)^3$$

Sample Coefficient of Variation

$$CV = \frac{s}{\bar{x}}$$

Simple Index Number

$$R = \frac{p_n}{p_0} \times 100$$

Laspeyres and Paasche Price Index Numbers

$$LPI = 100 \times \frac{\sum q_o p_n}{\sum q_o p_o}$$

$$PPI = 100 \times \frac{\sum q_n p_n}{\sum q_n p_o}$$

Laspeyres and Paasche Quantity Index Numbers

$$LQI = 100 \times \frac{\sum q_n p_0}{\sum q_o p_o}$$

$$PQI = 100 \times \frac{\sum q_n p_n}{\sum q_0 p_n}$$

Probability

$P(E_1 \text{ or } E_2) = P(E_1) + P(E_2) - P(E_1 \cap E_2)$

Theorem of Bayes

$$P(E|A) = \frac{P(A|E)P(E)}{P(A)}$$

Theorem of Total Probability

$$P(A) = \sum_i P(A|E_i)P(E_i)$$

Binomial Distribution $B(n, p)$

$$P(X = x) = \frac{n!}{x!(n-x)!} p^x (1-p)^{(n-x)}$$

$\mu = np \qquad \sigma = \sqrt{np(1-p)}$

Poisson Distribution $Po(\lambda)$

$$P(X = x) = \frac{e^{-\lambda}\lambda^x}{x!}$$

$\mu = \lambda \qquad \sigma = \sqrt{\lambda}$

Exponential Distribution

$f(t) = \lambda e^{-\lambda t},\ t \geq 0$

$P(T < t) = 1 - e^{-\lambda t}$

$\mu = \frac{1}{\lambda} \qquad \sigma = \frac{1}{\lambda}$

Standard Normal Distribution

$$z = \frac{x - \mu}{\sigma}$$

$$f(z) = \frac{e^{-z^2/2}}{\sqrt{2\pi}}$$

Hypothesis Testing

Distribution of sample means

$\mu_{\bar{x}} = \mu$ $\sigma_{\bar{x}} = \frac{\sigma}{\sqrt{n}}$

Large sample confidence interval of the mean $(n \geq 30)$

$$(\mu^-, \mu^+) = \left(\bar{x} - z_\gamma \frac{s}{\sqrt{n}}, \bar{x} + z_\gamma \frac{s}{\sqrt{n}}\right)$$

Large sample confidence interval of proportion (np and $n(1 - p) \geq 5$)

$$(p^-, p^+) = \left(\bar{p} - z_\gamma \sqrt{\frac{\bar{p}(1-\bar{p})}{n}}, \bar{p} + z_\gamma \sqrt{\frac{\bar{p}(1-\bar{p})}{n}}\right)$$

Exact confidence interval (underlying population has normal distribution)

$$(\mu^-, \mu^+) = \left(\bar{x} - t_\gamma \frac{s}{\sqrt{n}}, \bar{x} + t_\gamma \frac{s}{\sqrt{n}}\right)$$

Approximate large sample test of the mean

$$Z = \frac{\bar{x} - \mu}{s/\sqrt{n}}$$

Under the null hypothesis $Z \sim N(0, 1)$, approximately.

Student's one sample t-test of the mean.

$$T = \frac{\bar{x} - \mu}{s/\sqrt{n}}$$

Under the null hypothesis $T \sim t(n - 1)$

Independent two sample t-test

$$T = \frac{\overline{x_1} - \overline{x_2}}{s_p\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}} \qquad S_p^2 = \frac{(n_1-1)s_1^2 + (n_2-1)s_2^2}{n_1+n_2-2}$$

Under the null hypothesis $T \sim t(n_1 + n_2 - 2)$

Fitting Data

χ^2 Goodness of fit test ($E_i \geq 5$ for all i)

$\chi^2 = \sum_{i=1}^{k} \frac{(O_i - E_i)^2}{E_i}$

Under the null hypothesis $\chi^2 \sim \chi^2(k - m - 1)$

k is number of categories, m is number of model parameters estimated from data

χ^2 Test of Association ($E_i \geq 5$ for all i)

$\chi^2 = \sum_{i=1}^{k} \frac{(O_i - E_i)^2}{E_i}$

Under the null hypothesis $\chi^2 \sim \chi^2\big((r - 1)(c - 1)\big)$

r is number of rows, c is number of columns

Simple Linear Regression

$\hat{y} = \mathrm{m}x_\mathrm{i} + \mathrm{c}$ is the least SSE straight line where;

$\mathrm{m} = \frac{\sum(x_\mathrm{i} - \bar{x})(y_\mathrm{i} - \bar{y})}{\sum(x_i - \bar{x})^2}$ $\quad$ $\mathrm{m} = \frac{\mathrm{n}\sum x_\mathrm{i} y_\mathrm{i} - \sum x_\mathrm{i} \sum y_\mathrm{i}}{\mathrm{n}\sum x_\mathrm{i}^2 - (\sum x_\mathrm{i})^2}$

$\mathrm{c} = \bar{y} - \mathrm{m}\bar{x}$

The Coefficient of Determination

$$R^2 = r^2 = \frac{\sum\left(\hat{y} - \bar{y}\right)^2}{\sum(y - \bar{y})^2}$$

The Pearson Correlation Function

$$\mathrm{R} = \mathrm{r} = \frac{\mathrm{n}\sum x_\mathrm{i} y_\mathrm{i} - \sum x_\mathrm{i} \sum y_\mathrm{i}}{\sqrt{(\mathrm{n}\sum x_\mathrm{i}^2 - (\sum x_\mathrm{i})^2)(\mathrm{n}\sum y_\mathrm{i}^2 - (\sum y_\mathrm{i})^2)}}$$

Spearman's Rank Correlation (with no ties)

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

Differentiation

Definition

$$f'(x) = \frac{dy}{dx} = \lim_{\Delta x \to 0} \frac{f(x + \Delta x) - f(x)}{\Delta x}$$

Standard Derivatives

$\boldsymbol{y}$	$\boldsymbol{\frac{dy}{dx}}$
$y = ax^n$	$\frac{dy}{dx} = nax^{\mathrm{n}-1}$
$y = \mathrm{e}^{\mathrm{a}x}$	$\frac{dy}{dx} = a\mathrm{e}^{\mathrm{a}x}$
$y = ln(ax)$ $= log_{\mathrm{e}}(x)$	$\frac{dy}{dx} = \frac{1}{x}$

Rules of Differentiation

$$\frac{d}{dx}\big(af(x) + bg(x)\big) = a\frac{df}{dx} + b\frac{dg}{dx}$$

$$\frac{d}{dx}\big(f(x)g(x)\big) = f(x)\frac{dg}{dx} + g(x)\frac{df}{dx}$$

$$\frac{d}{dx}\Big(f\big(g(x)\big)\Big) = \frac{df}{dg}\frac{dg}{dx}$$

$$\frac{d}{dx}\left(\frac{f(x)}{g(x)}\right) = \frac{g(x)\frac{df}{dx} - f(x)\frac{dg}{dx}}{\big(g(x)\big)^2}$$

Elasticities of Demand

Own price	Cross price	Income
$E_p = \frac{\partial Q_1}{\partial p_1}\frac{p_1}{Q_1}$	$E_{12} = \frac{\partial Q_1}{\partial p_2}\frac{p_2}{Q_1}$	$E_I = \frac{\partial Q_1}{\partial I}\frac{I}{Q_1}$

The Total Differential

$$y = y(x_1 + x_2 + x_3 + \ldots)$$

$$dy = \frac{\partial y}{\partial x_1}dx_1 + \frac{\partial y}{\partial x_2}dx_2 + \frac{\partial y}{\partial x_3}dx_3 + \ldots$$

$$\Delta y \approx \frac{\partial y}{\partial x_1}\Delta x_1 + \frac{\partial y}{\partial x_2}\Delta x_2 + \frac{\partial y}{\partial x_3}\Delta x_3 + \ldots$$

Time series

The additive decomposition model

$Y_n = T_n + S_n + I_n$

The multiplicative decomposition model

$Y_n = T_n \times S_n \times I_n$

Three Point Moving Average

$T_n = \frac{1}{3}(Y_{n-1} + Y_n + Y_{n+1})$

Four Point Centred Moving Average

$T_n = \frac{1}{8}(Y_{n-2} + 2Y_{n-1} + 2Y_n + 2Y_{n+1} + Y_{n+2})$

Simple Exponential Smoothing

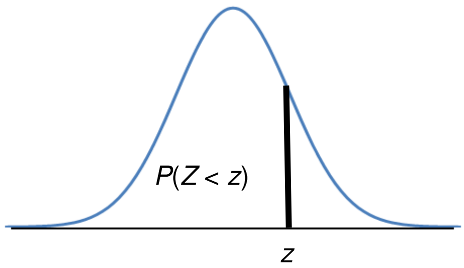
$F_{t+1} = \alpha Y_t + (1 - \alpha) F_t$

Errors

$$MSE = \frac{1}{N}\sum_{j=1}^{N}\left(Y_j - F_j\right)^2$$

$$MAE = \frac{1}{N}\sum_{j=1}^{N}\left|Y_j - F_j\right|$$

Probabilities under the Normal Distribution Curve

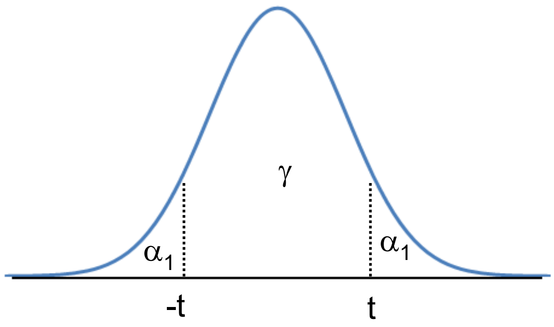


z	0	1	2	3	4	5	6	7	8	9
-3.50	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
-3.40	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002
-3.30	0.0005	0.0005	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0003
-3.20	0.0007	0.0007	0.0006	0.0006	0.0006	0.0006	0.0006	0.0005	0.0005	0.0005
-3.10	0.0010	0.0009	0.0009	0.0009	0.0008	0.0008	0.0008	0.0008	0.0007	0.0007
-3.00	0.0013	0.0013	0.0013	0.0012	0.0012	0.0011	0.0011	0.0011	0.0010	0.0010
-2.90	0.0019	0.0018	0.0018	0.0017	0.0016	0.0016	0.0015	0.0015	0.0014	0.0014
-2.80	0.0026	0.0025	0.0024	0.0023	0.0023	0.0022	0.0021	0.0021	0.0020	0.0019
-2.70	0.0035	0.0034	0.0033	0.0032	0.0031	0.0030	0.0029	0.0028	0.0027	0.0026
-2.60	0.0047	0.0045	0.0044	0.0043	0.0041	0.0040	0.0039	0.0038	0.0037	0.0036
-2.50	0.0062	0.0060	0.0059	0.0057	0.0055	0.0054	0.0052	0.0051	0.0049	0.0048
-2.40	0.0082	0.0080	0.0078	0.0075	0.0073	0.0071	0.0069	0.0068	0.0066	0.0064
-2.30	0.0107	0.0104	0.0102	0.0099	0.0096	0.0094	0.0091	0.0089	0.0087	0.0084
-2.20	0.0139	0.0136	0.0132	0.0129	0.0125	0.0122	0.0119	0.0116	0.0113	0.0110
-2.10	0.0179	0.0174	0.0170	0.0166	0.0162	0.0158	0.0154	0.0150	0.0146	0.0143
-2.00	0.0228	0.0222	0.0217	0.0212	0.0207	0.0202	0.0197	0.0192	0.0188	0.0183
-1.90	0.0287	0.0281	0.0274	0.0268	0.0262	0.0256	0.0250	0.0244	0.0239	0.0233
-1.80	0.0359	0.0351	0.0344	0.0336	0.0329	0.0322	0.0314	0.0307	0.0301	0.0294
-1.70	0.0446	0.0436	0.0427	0.0418	0.0409	0.0401	0.0392	0.0384	0.0375	0.0367
-1.60	0.0548	0.0537	0.0526	0.0516	0.0505	0.0495	0.0485	0.0475	0.0465	0.0455
-1.50	0.0668	0.0655	0.0643	0.0630	0.0618	0.0606	0.0594	0.0582	0.0571	0.0559
-1.40	0.0808	0.0793	0.0778	0.0764	0.0749	0.0735	0.0721	0.0708	0.0694	0.0681
-1.30	0.0968	0.0951	0.0934	0.0918	0.0901	0.0885	0.0869	0.0853	0.0838	0.0823
-1.20	0.1151	0.1131	0.1112	0.1093	0.1075	0.1056	0.1038	0.1020	0.1003	0.0985
-1.10	0.1357	0.1335	0.1314	0.1292	0.1271	0.1251	0.1230	0.1210	0.1190	0.1170
-1.00	0.1587	0.1562	0.1539	0.1515	0.1492	0.1469	0.1446	0.1423	0.1401	0.1379
-0.90	0.1841	0.1814	0.1788	0.1762	0.1736	0.1711	0.1685	0.1660	0.1635	0.1611
-0.80	0.2119	0.2090	0.2061	0.2033	0.2005	0.1977	0.1949	0.1922	0.1894	0.1867
-0.70	0.2420	0.2389	0.2358	0.2327	0.2296	0.2266	0.2236	0.2206	0.2177	0.2148
-0.60	0.2743	0.2709	0.2676	0.2643	0.2611	0.2578	0.2546	0.2514	0.2483	0.2451
-0.50	0.3085	0.3050	0.3015	0.2981	0.2946	0.2912	0.2877	0.2843	0.2810	0.2776
-0.40	0.3446	0.3409	0.3372	0.3336	0.3300	0.3264	0.3228	0.3192	0.3156	0.3121
-0.30	0.3821	0.3783	0.3745	0.3707	0.3669	0.3632	0.3594	0.3557	0.3520	0.3483
-0.20	0.4207	0.4168	0.4129	0.4090	0.4052	0.4013	0.3974	0.3936	0.3897	0.3859
-0.10	0.4602	0.4562	0.4522	0.4483	0.4443	0.4404	0.4364	0.4325	0.4286	0.4247
-0.00	**0.5000**	**0.4960**	**0.4920**	**0.4880**	**0.4840**	**0.4801**	**0.4761**	**0.4721**	**0.4681**	**0.4641**

z	0	1	2	3	4	5	6	7	8	9
0.00	**0.5000**	**0.5040**	**0.5080**	**0.5120**	**0.5160**	**0.5199**	**0.5239**	**0.5279**	**0.5319**	**0.5359**
0.10	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.20	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.30	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.40	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.50	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.60	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.70	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.80	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.90	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.00	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.10	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.20	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.30	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.40	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.50	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.60	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.70	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.80	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.90	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.00	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.10	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.20	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.30	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.40	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.50	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.60	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.70	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.80	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.90	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3.00	0.9987	0.9987	0.9987	0.9988	0.9988	0.9989	0.9989	0.9989	0.9990	0.9990
3.10	0.9990	0.9991	0.9991	0.9991	0.9992	0.9992	0.9992	0.9992	0.9993	0.9993
3.20	0.9993	0.9993	0.9994	0.9994	0.9994	0.9994	0.9994	0.9995	0.9995	0.9995
3.30	0.9995	0.9995	0.9995	0.9996	0.9996	0.9996	0.9996	0.9996	0.9996	0.9997
3.40	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9998
3.50	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998

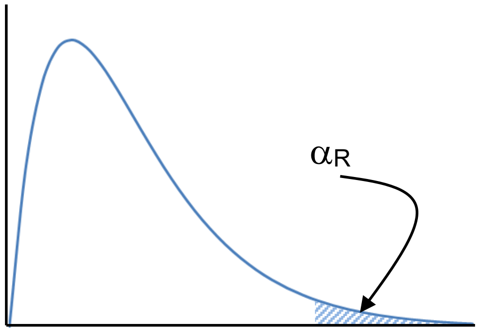
Percentage Points of the Student t Distribution

α_1	**5.00%**	2.50%	**1.00%**	**0.50%**
α_2	10.00%	**5.00%**	2.00%	**1.00%**
γ	90.00%	**95.00%**	98.00%	**99.00%**
df 1	6.3138	12.7062	31.8205	63.6567
2	2.9200	4.3027	6.9646	9.9248
3	2.3534	3.1824	4.5407	5.8409
4	2.1318	2.7764	3.7469	4.6041
5	2.0150	2.5706	3.3649	4.0321
6	1.9432	2.4469	3.1427	3.7074
7	1.8946	2.3646	2.9980	3.4995
8	1.8595	2.3060	2.8965	3.3554
9	1.8331	2.2622	2.8214	3.2498
10	1.8125	2.2281	2.7638	3.1693
11	1.7959	2.2010	2.7181	3.1058
12	1.7823	2.1788	2.6810	3.0545
13	1.7709	2.1604	2.6503	3.0123
14	1.7613	2.1448	2.6245	2.9768
15	1.7531	2.1314	2.6025	2.9467
16	1.7459	2.1199	2.5835	2.9208
17	1.7396	2.1098	2.5669	2.8982
18	1.7341	2.1009	2.5524	2.8784
19	1.7291	2.0930	2.5395	2.8609
20	1.7247	2.0860	2.5280	2.8453
21	1.7207	2.0796	2.5176	2.8314
22	1.7171	2.0739	2.5083	2.8188
23	1.7139	2.0687	2.4999	2.8073
24	1.7109	2.0639	2.4922	2.7969
25	1.7081	2.0595	2.4851	2.7874
26	1.7056	2.0555	2.4786	2.7787
27	1.7033	2.0518	2.4727	2.7707
28	1.7011	2.0484	2.4671	2.7633
29	1.6991	2.0452	2.4620	2.7564
30	1.6973	2.0423	2.4573	2.7500
31	1.6955	2.0395	2.4528	2.7440
32	1.6939	2.0369	2.4487	2.7385
33	1.6924	2.0345	2.4448	2.7333
34	1.6909	2.0322	2.4411	2.7284
35	1.6896	2.0301	2.4377	2.7238
36	1.6883	2.0281	2.4345	2.7195
37	1.6871	2.0262	2.4314	2.7154
38	1.6860	2.0244	2.4286	2.7116
39	1.6849	2.0227	2.4258	2.7079
40	1.6839	2.0211	2.4233	2.7045
∞	**1.6449**	**1.9600**	**2.3263**	**2.5758**



Critical Values for the χ^2 Distribution

α_R / df	0.05 **5.00%**	0.01 **1.00%**
1	3.841	6.635
2	5.991	9.210
3	7.815	11.345
4	9.488	13.277
5	11.070	15.086
6	12.592	16.812
7	14.067	18.475
8	15.507	20.090
9	16.919	21.666
10	18.307	23.209
11	19.675	24.725
12	21.026	26.217
13	22.362	27.688
14	23.685	29.141
15	24.996	30.578
16	26.296	32.000
17	27.587	33.409
18	28.869	34.805
19	30.144	36.191
20	31.410	37.566
21	32.671	38.932
22	33.924	40.289
23	35.172	41.638
24	36.415	42.980
25	37.652	44.314
26	38.885	45.642
27	40.113	46.963
28	41.337	48.278
29	42.557	49.588
30	43.773	50.892



Learning Outcomes matrix

Question	Learning Outcomes assessed	Marker can differentiate between varying levels of achievement
1	1,2,3,4	Yes
2	1	Yes
3	2, 4	Yes
4	3	Yes
5	1,2,4	Yes
6	1,2,3	Yes

Grade descriptors

Learning Outcome	Pass	Merit	Distinction
Use summary and inferential statistics to inform business decisions.	Demonstrate adequate and appropriate use of statistics.	Demonstrate appropriate and effective use of statistics.	Demonstrate highly appropriate and effective use of statistics.
Analyse management decisions using optimisation techniques.	Demonstrate adequate ability to analyse decisions.	Demonstrate ability to provide detailed and coherent analysis of decisions.	Demonstrate ability to provide comprehensive, lucid analysis of decisions.
Understand and apply approaches to business forecasting.	Demonstrate ability to perform the task.	Demonstrate ability to perform the task consistently well.	Demonstrate ability to perform the task to the highest standard.
Evaluate sequential management decisions.	Provide a reasonable assessment of the subject; Ideas are generally coherent.	Provide a generally strong assessment with some well-reasoned assumptions; Ideas are consistently coherent.	Provide a consistently strong assessment with well-reasoned and original assumptions; All ideas are highly coherent.