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	I declare this is my own work.		

INTERNATIONAL A-LEVEL MATHEMATICS

(9660/MA04) Unit S2 Statistics

Friday 13 January 2023 07:00 GMT Time allowed: 1 hour 30 minutes

Materials

- For this paper you must have the Oxford International AQA Booklet of Formulae and Statistical Tables (enclosed).
- You may use a graphical calculator.

Instructions

- Use black ink or black ball-point pen. Pencil should only be used for drawing.
- Fill in the boxes at the top of this page.
- Answer all questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- Do all rough work in this book. Cross through any work you do not want to be marked.

For Examiner's Use	
Question	Mark
1	
2	
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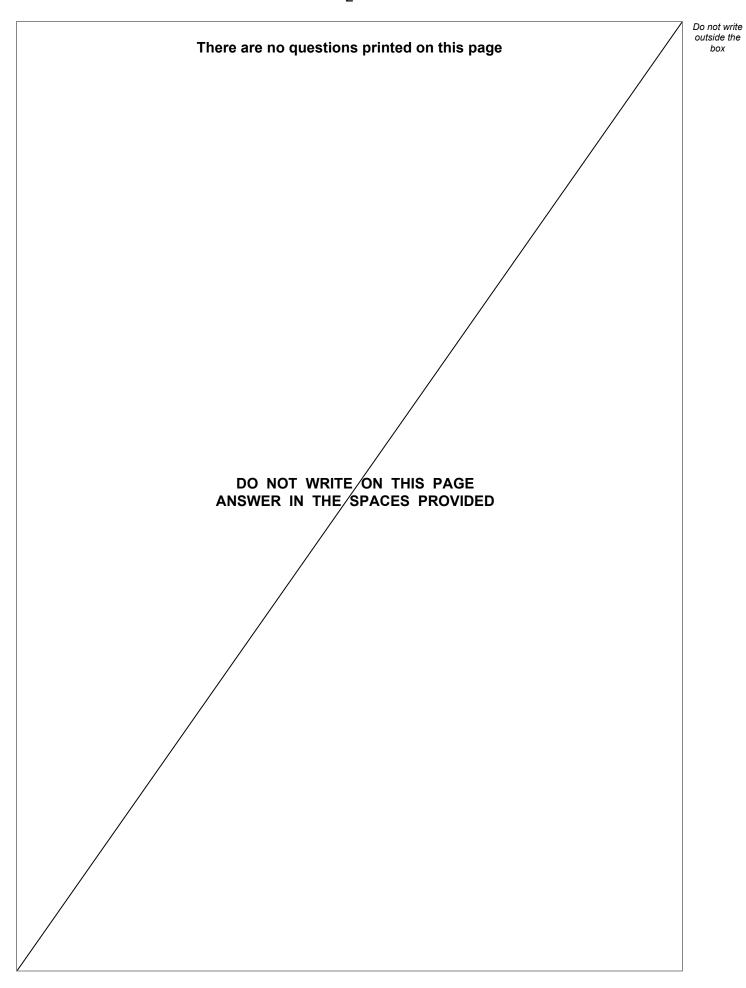
Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 80.

Advice

- Unless stated otherwise, you may quote formulae, without proof, from the booklet.
- Show all necessary working; otherwise marks may be lost.







	Answer all questions in the spaces provided.	ou
1	The continuous random variable $ X $ has mean 12 and variance 5 The continuous random variable $ Y $ has mean 15 and variance 2.5	
	The random variables X and Y are independent.	
1 (a)	Find the value of $E(3Y-2X)$	[2 marks]
	Answer	
1 (b)	Find the value of $Var(3Y-2X)$	[2 marks]
	Answer	



A hypothesis test is carried out by a student to determine whether there is evidence that the mean μ of a normally distributed random variable X has changed from 18.3

A random sample of size 16 has a sample mean of 19

The standard deviation of X is known to be 2.5

A 10% level of significance is used.

There are errors in **three** stages of the student's attempt at the hypothesis test below.

	Statement	
Stage 1	$H_0: \overline{x} = 18.3$ $H_1: \overline{x} \neq 18.3$	
Stage 2	Under H_0 $X \sim N(18.3, 2.5^2)$	
Stage 3	$n = 16$ $\overline{X} \sim N\left(18.3, \frac{2.5^2}{16}\right)$	
Stage 4	10% level of significance gives $z_{critical} = \pm 1.2816$	
Using sample mean = 19 $z = \frac{19 - 18.3}{\left(\frac{2.5}{4}\right)}$		
Stage 6	Test statistic $z = 1.12$	
Stage 7	$Z \le Z_{ m critical}$	
Stage 8	As we have evidence to suggest a change in mean occurred at the 10% level of significance, we reject ${\rm H}_0$	

2 (a) Identify the **three** stages with errors and write down the correct statements for each of the stages.

[4 marks]

Error 1 Stage

Correct statement

	Error 2	Stage	outside box
		Correct statement	
	Error 3	Stage	
		Correct statement	
2 (b)	Explain v	hy the Central Limit Theorem is not needed in the student's h	ypothesis test. [1 mark]
2 (c)	Which of	the five options below correctly completes the following sente	nce?
		_ is the set of values for the test statistic for which we reject th	e null hypothesis.
	Tick (✓)	one box.	[1 mark]
		A Confidence Interval	
		A Critical Region	
		An Unbiased Estimator	
		A Critical Value	
		A Significance Test	6



3		The continuous random variable T has the cumulative distribution function	
		$F(t) = \begin{cases} 0 & t < 0 \\ \frac{t^3}{64} & 0 \le t \le 4 \\ 1 & t > 4 \end{cases}$	
3	(a)	Find the probability density function of $\ T$ for all values of $\ t$	[3 marks]
		Answer	
3	(b)	The mean of T is μ and the standard deviation of T is σ	
3	(b) (i)	Find the value of μ	[2 marks]
		Answer	



3	(b) (ii)	Find the value of σ	
		Give your answer to three significant figures. [4 marks]	
		Answer	
3	(c)	Find $P(\mu-2\sigma \le T \le \mu+2\sigma)$	
		Give your answer to three significant figures. [4 marks]	
		Answer	

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Hand-drying machines are designed to switch off automatically after a set drying time.			
A manufacturer makes hand-drying machines which have a mean drying time of 25 seconds.			
An engineer redesigns the hand-drying machine and a random sample of 500 redesigned machines are tested.			
The drying time, $\ X$ seconds, is measured for each of the redesigned machines and the results are summarised as			
$\sum x = 12430$ and $\sum x^2 = 310000$			
The engineer now claims that the mean drying time has been reduced.			
Test the engineer's claim at the 1% level of significance. [10 marks]			







5	(a) (i)	(i) State two conditions required for using a Poisson distribution as an approximation binomial distribution $B(n, p)$	
		binomial distribution $B(n, p)$	[1 mark]
		Condition 1	
		Condition 2	
5	(a) (ii)	It is given that $X \sim B(500, 0.02)$	
		Use a Poisson approximation to find the parameter $\ \lambda$ for this distribution.	[1 mark]
		Answer	
5	(a) (iii)	Using your Poisson approximation for X find $P(X \le 10)$	
		Give your answer to three significant figures.	
			[2 marks]
		Answer	



5	(b)	Yellow jacket wasps live in ground nests found on farmland.
		The number of ground nests found on farmland is known to fit a Poisson distribution with a mean of 8 per hectare.
		Sally has a farm which has trialled a new crop.
		Sally believes that the new crop has caused a change in the Poisson distribution mean number of ground nests for yellow jacket wasps.
		Over 30 hectares Sally finds 150 ground nests for yellow jacket wasps.
5	(b) (i)	Construct a hypothesis test for Sally's claim at the 10% level of significance. [6 marks]
		Ougstion E continues on the next ness
		Question 5 continues on the next page





(D) (II	Find the critical region for the hypothesis test in part (b)(i) at the 10% level of	
	significance.	[3 marks]
	Answer	
(c) (i)	Describe in the context of the test in part (b)(i) a Type I error.	[1 mark]
(c) (ii	Calculate the probability of a Type I error for the test in part (b)(i) .	[1 mark]
	Δπανιστ	
	Answer	



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6		independent normal distributions as shown below.		
		Vertical Slide	$X_1 \sim N(12, 1.5^2)$	
		High Swings	$X_2 \sim N(8, 0.8^2)$	
		Gravity Wheel	$X_3 \sim N(7, 1^2)$	
		Roller Coaster	$X_4 \sim N(14, 2^2)$	
		Jump Drop	$X_5 \sim N(\mu, \sigma^2)$	
6	(a)	Find the probability that the queue time	for the Vertical Slide is less than 10 minutes.	
		Give your answer to three significant fig	ures. [2 marks]	
		Answer_		
6 (b)		Find the queue time exceeded by 10% of people for the High Swings.		
		Give your answer to three significant fig	ures. [3 marks]	
		Answer_		

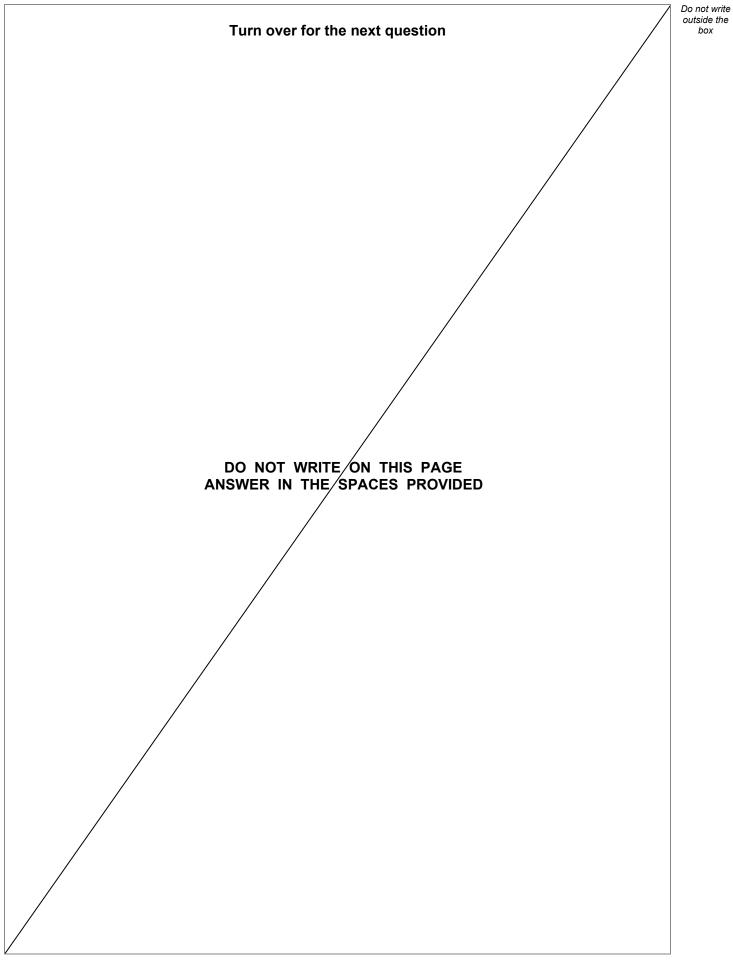


6	(c)	For the Jump Drop it	is given that			
			$P(X_5 < 16) = 0.82$	and	$P(X_5 > 10) = 0.53$	
		Find the value of μ	and the value of σ			
		Give your answers to	three significant figu	ıres.		IC was a wheal
						[6 marks]
			$\mu = $		$\sigma =$	
		Qı	uestion 6 continues			



	Find $P(T < 35)$ Give your answer to three significant figures.	[3 marks]
	The total queue time is $\ensuremath{\mathit{T}}$ minutes.	
(e)	A person queues once for each of the Vertical Slide, High Swings, Gravity Wh	neel and
	as this normal distribution might not be appropriate in this context.	[1 mark]







7		Don runs a business where people make appointments to ride ponies.	
		The number of appointments made by customers for rides each week can be no by a Poisson distribution with $\lambda=2.5$	nodelled
7	(a)	Find the probability that there are exactly four appointments in a given week.	
		Give your answer to four significant figures.	[2 marks]
		Answer	
7	(b)	The summer holiday period lasts 6 weeks.	
		Find the probability that there are more than 18 appointments over the summer period.	holiday
		Give your answer to four significant figures.	[3 marks]
		Answer	



7	(c)	The time, ${\cal T}$ weeks, between appointments can be modelled by an exponential distribution.	
7	(c) (i)	Find the mean of $\ensuremath{\mathit{T}}$	mark]
		Answer	
7	(c) (ii)	Find the variance of $\it T$	mark]
		Answer	
7	(d)	A week lasts 7 days.	
		Find the value of c such that $P(T < c) = 0.9$	
		Give your answer to the nearest day. [3 m	arks]
		Answer	

10



8 The probability density function f for a continuous random variable X is given by

$$f(x) = \begin{cases} \frac{96}{(5x+k)^2} & 2 \le x \le d \\ 0 & \text{otherwise} \end{cases}$$

where k and d are constants, k > 0 and d > 2

8 (a) Show that the cumulative distribution function F for X is given by

$$F(x) = \begin{cases} 0 & x < 2 \\ \frac{96(x-2)}{(10+k)(5x+k)} & 2 \le x \le d \\ 1 & x > d \end{cases}$$

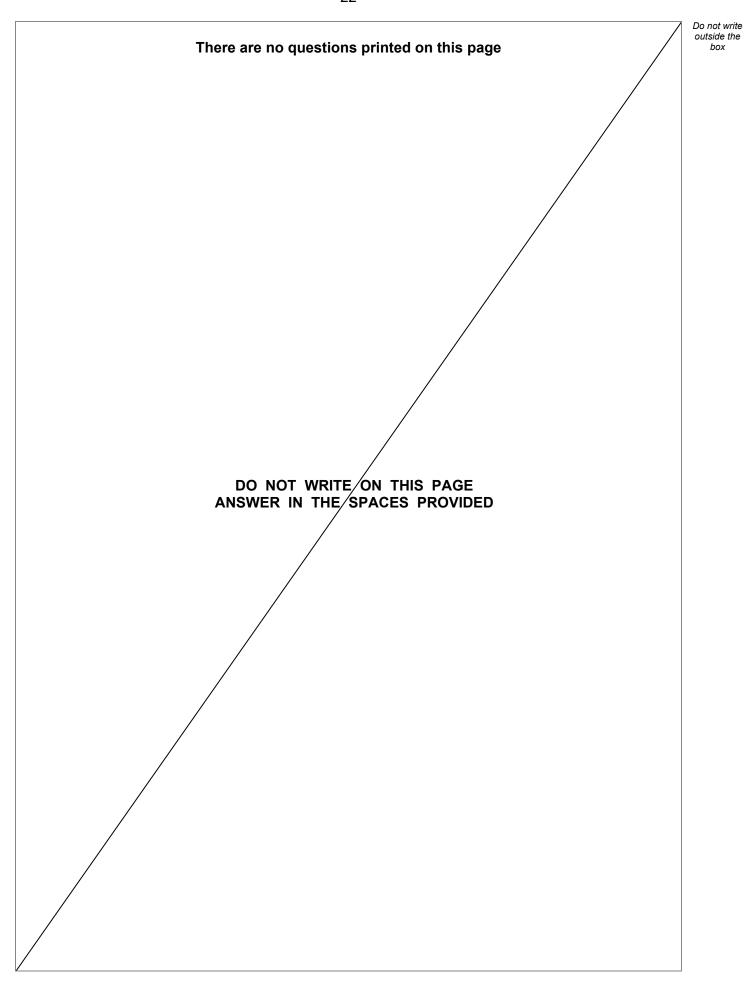
[4 marks]



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8 (b)	It is given that $F(4.4) = 0.8$	
o (b)	1 13 given that 1 (4.4) 0.0	
	Find the value of k	
		[3 marks]
	Anguar	$\left \left \frac{}{7} \right \right $
	Answer	L

END OF QUESTIONS







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