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Pearson Edexcel Level 3 GCE

Mathematics

Advanced Subsidiary
Paper 2: Statistics and Mechanics

Sample assessment material for first teaching September 2017 **Time: 1 hour 15 minutes**	Paper Reference(s) **8MA0/02**

You must have:
Mathematical Formulae and Statistical Tables
Calculator

Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for algebraic manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- There are **two** sections in this question paper. Answer **all** the questions in Section A and **all** the questions in Section B.
- Answer the questions in the spaces provided
  - *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Inexact answers should be given to three significant figures unless otherwise stated.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 9 questions in this question paper. The total mark for this paper is 60.
- The marks for each question are shown in brackets
  - *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

SECTION A: STATISTICS

Answer ALL questions. Write your answers in the spaces provided.

1. Sara is investigating the variation in daily maximum gust, t kn, for Camborne in June and July 1987.

She used the large data set to select a sample of size 20 from the June and July data for 1987. Sara selected the first value using a random number from 1 to 4 and then selected every third value after that.

(a) State the sampling technique Sara used.

(1)

(b) From your knowledge of the large data set, explain why this process may not generate a sample of size 20.

(1)

The data Sara collected are summarised as follows

$$n = 20 \qquad \sum t = 374 \qquad \sum t^2 = 7600$$

(c) Calculate the standard deviation.

(2)

a/ Systemmatic

b/ Some of the data may be missing. There are gaps.

c) $\sigma^2 = \frac{7600}{20} - \left(\frac{374}{20}\right)^2$

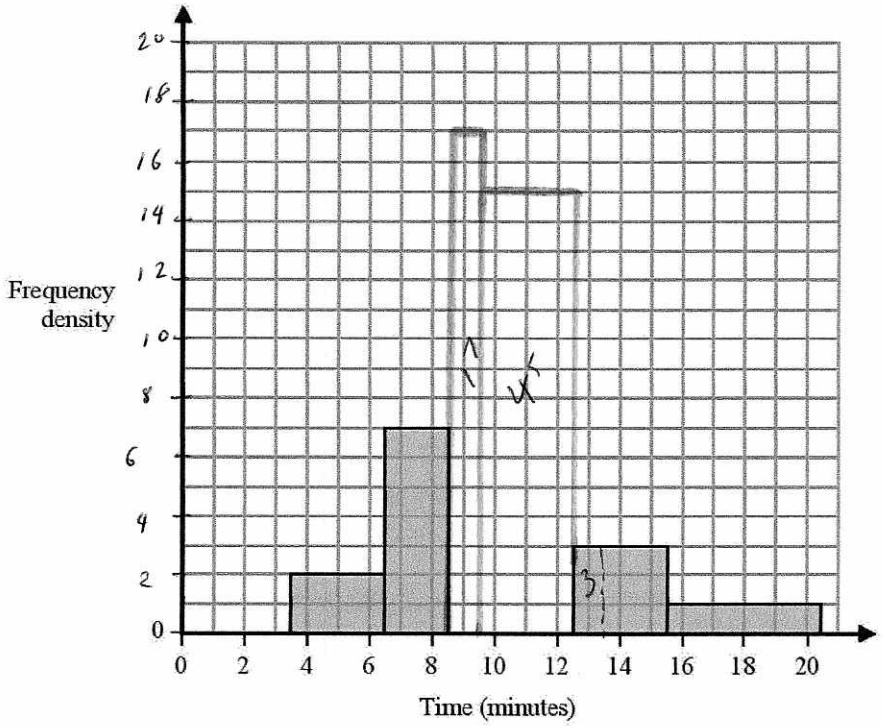
$\sigma^2 = 30.31$

$\sigma = \sqrt{30.31}$

$= 5.50$ (3sf)

$= 5.51$ (3sf)

2. The partially completed histogram and the partially completed table show the time, to the nearest minute, that a random sample of motorists were delayed by roadworks on a stretch of motorway.



Delay (minutes)	C.W	Number of motorists	F.d
3.5 4–6 6.5	3	6	2
6.5 7–8 8.5	2	14	7
8.5 9 9.5	1	17	17
9.5 10–12 12.5	3	45	15
12.5 13–15 15.5	3	9	3
15.5 16–20 20.5	5	5	1
		96	

Estimate the percentage of these motorists who were delayed by the roadworks for between 8.5 and 13.5 minutes.

(5)

8.5 → 9.5 17

9.5 → 12.5 45

12.5 → 15.5 9 ÷ 3 = 3

$\frac{65}{96} \times 100 = 67.7\%$ 1dp

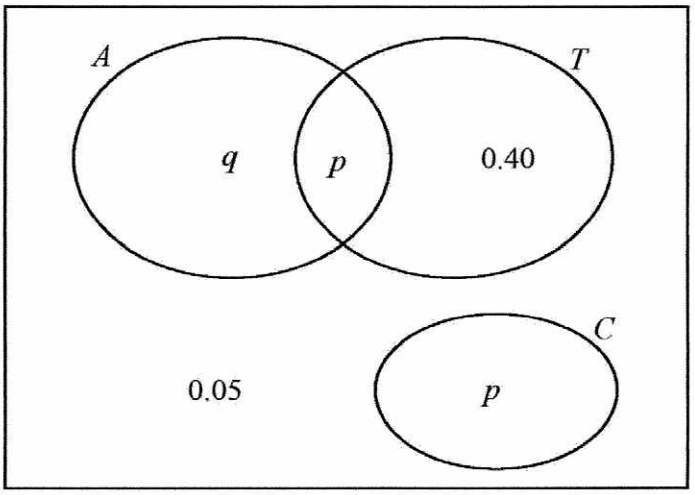
3. The Venn diagram shows the probabilities for students at a college taking part in various sports.

A represents the event that a student takes part in Athletics.

T represents the event that a student takes part in Tennis.

C represents the event that a student takes part in Cricket.

p and q are probabilities.



The probability that a student selected at random takes part in Athletics or Tennis is 0.75

(a) Find the value of p.

(1)

(b) State, giving a reason, whether or not the events A and T are statistically independent. Show your working clearly.

(3)

(c) Find the probability that a student selected at random does not take part in Athletics or Cricket.

(1)

a/ $p = 1 - 0.75 - 0.05$

$= 0.2$

b/ $q = 1 - 0.4 - 0.05 - 2(0.2)$

$= 0.15$

A and T are independent if $P(A \cap T) = P(A) \times P(T)$

Question 3 continued

$P(A) = 0.2 + 0.15 = 0.35$

$P(T) = 0.4 + 0.2 = 0.6$

$0.6 \times 0.35 = 0.21 \qquad 0.21 \neq 0.2$

They are not independent.

c) 0.45

(Total for Question 3 is 5 marks)

4. Sara was studying the relationship between rainfall, r mm, and humidity, h %, in the UK. She takes a random sample of 11 days from May 1987 for Leuchars from the large data set.

She obtained the following results.

h	93	86	95	97	86	94	97	97	87	97	86
r	1.1	0.3	3.7	20.6	0	0	2.4	1.1	0.1	0.9	0.1

Sara examined the rainfall figures and found

$$Q_1 = 0.1 \quad Q_2 = 0.9 \quad Q_3 = 2.4$$

A value that is more than 1.5 times the interquartile range (IQR) above Q_3 is called an outlier.

(a) Show that $r = 20.6$ is an outlier.

(1)

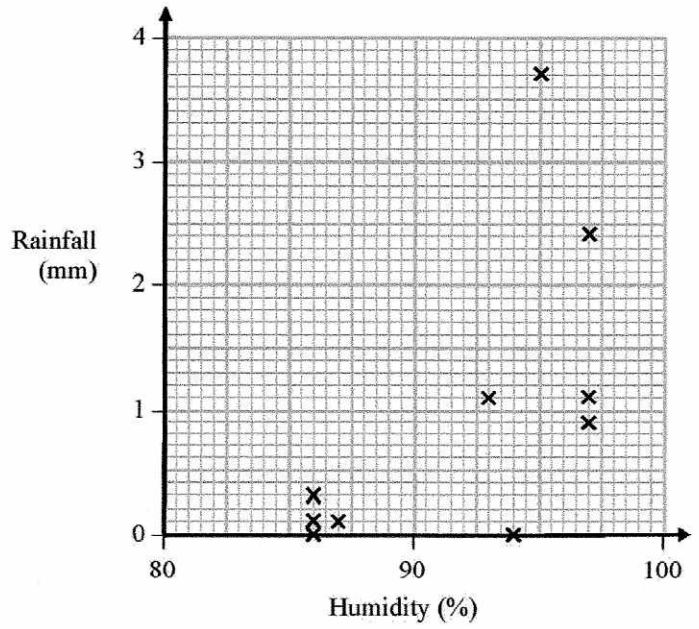
(b) Give a reason why Sara might (i) include

(ii) exclude

this day's reading.

(2)

Sara decided to exclude this day's reading and drew the following scatter diagram for the remaining 10 days' values of r and h.



(c) Give an interpretation of the correlation between rainfall and humidity.

(1)

Question 4 continued

The equation of the regression line of r on h for these 10 days is $r = -12.8 + 0.15h$

(d) Give an interpretation of the gradient of this regression line.

(1)

(e) (i) Comment on the suitability of Sara's sampling method for this study.

(ii) Suggest how Sara could make better use of the large data set for her study.

(2)

a/ IQR = 2.4 − 0.1

= 2.3

1.5 × 2.3 = 3.45

2.4 + 3.45 = 5.85

Anything above 5.85 is an outlier.

∴ 20.6 is an outlier.

b i/ It is a piece of data just like the others

ii/ It may be an error / it will have a significant affect on the results (extreme value)

c/ As the humidity increases the rainfall increases.

d/ For each 1% incr. in humidity rainfall incr. by 0.15mm

e i/ Not suitable as she only uses one month and one location

Total for Question 4 is 7 marks)

4

Question 2 continued

ii) Sara could use data from more UK locations and more months.

4 1

(Total for Question 2 is 5 marks)

5. (a) The discrete random variable $X \sim B(40, 0.27)$

Find $P(X \geqslant 16)$

(2)

Past records suggest that 30% of customers who buy baked beans from a large supermarket buy them in single tins. A new manager suspects that there has been a change in the proportion of customers who buy baked beans in single tins. A random sample of 20 customers who had bought baked beans was taken.

(b) Write down the hypotheses that should be used to test the manager's suspicion.

(1)

(c) Using a 10% level of significance, find the critical region for a two-tailed test to answer the manager's suspicion. You should state the probability of rejection in each tail, which should be less than 0.05

(3)

(d) Find the actual significance level of a test based on your critical region from part (c).

(1)

One afternoon the manager observes that 12 of the 20 customers who bought baked beans, bought their beans in single tins.

(e) Comment on the manager's suspicion in the light of this observation.

(1)

Later it was discovered that the local scout group visited the supermarket that afternoon to buy food for their camping trip.

(f) Comment on the validity of the model used to obtain the answer to part (e), giving a reason for your answer.

(1)

a/ (Binomial C.D.)

$P(X \leq 15) = 0.9490771841$

$1 - 0.9490771841 = 0.0509228159$

$= 0.0509$ 3sf

b/ $H_0 : p = 0.3$

$H_1 : p \neq 0.3$

Question 5 continued

c/ $N = 20 \quad p = 0.30$

$X \leqslant 2$ 0.0355 chance of rejection

$X \geqslant 9$ $1 - 0.9520 = 0.0480$ chance of rejection

CRITICAL REGION $X \leqslant 2 \quad X \geqslant 10$

d/ $0.0355 + 0.048 = 0.0835$

e/ 12 is in the critical region so the Manager's claim is supported.

f/ This suggests that the model is not valid because the 20 customers were not representitive of all customers.

(Total for Question 5 is 9 marks)

TOTAL FOR SECTION A IS 30 MARKS

SECTION B: MECHANICS

Answer ALL questions. Write your answers in the spaces provided.

Unless otherwise indicated, whenever a numerical value of g is required, take $g = 9.8$ m s^{-2} and give your answer to either 2 significant figures or 3 significant figures.

6.

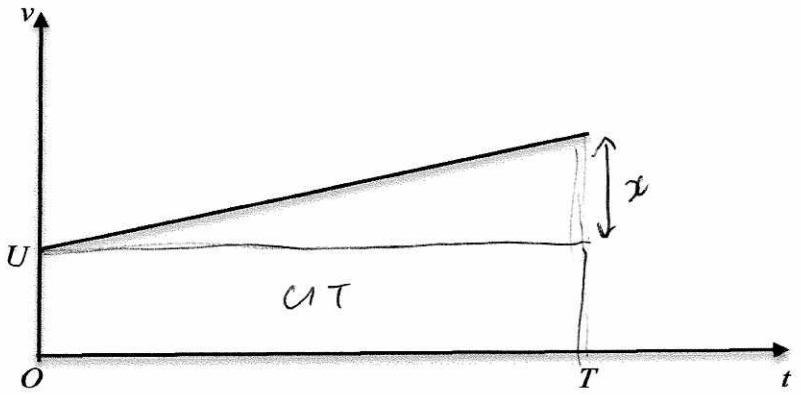


Figure 1

A car moves along a straight horizontal road. At time $t = 0$, the velocity of the car is U m s^{-1}. The car then accelerates with constant acceleration a m s^{-2} for T seconds. The car travels a distance D metres during these T seconds.

Figure 1 shows the velocity-time graph for the motion of the car for $0 \leqslant t \leqslant T$.

Using the graph, show that $D = UT + \frac{1}{2}aT^2$.

(No credit will be given for answers which use any of the kinematics (*suvat*) formulae listed under Mechanics in the AS Mathematics section of the formulae booklet.)

(4)

$D = UT + \frac{1}{2} \times T$ (distance = area under graph)

$a = \frac{x}{T}$ (acceleration = gradient)

$x = aT$ $\therefore$ $D = UT + \frac{1}{2}(aT)T$

$D = UT + \frac{1}{2}aT^2$

7. A car is moving along a straight horizontal road with constant acceleration.

There are three points A, B and C, in that order, on the road, where $AB = 22$ m and $BC = 104$ m.

The car takes 2 s to travel from A to B and 4 s to travel from B to C.

Find

(i) the acceleration of the car,

(ii) the speed of the car at the instant it passes A.

(7)

$A \rightarrow B$

$s = 22$

$u = u$

v

$a = a$

$t = 2$

$B \rightarrow C$

$s = 104$

u

v

a

$t = 4$

$A \rightarrow B$

$s = ut + \frac{1}{2}at^2$

$22 = 2u + \frac{1}{2}a(2)^2$

$22 = 2u + 2a$

$11 = u + a$

$(u = 11 - a)$

$B \rightarrow C$

$s = 126$

$u = u$

$v =$

$a = a$

$t = 6$

$A \rightarrow C$

$s = ut + \frac{1}{2}at^2$

$126 = 6u + \frac{1}{2}a(6)^2$

$126 = 6u + 18a$

$21 = u + 3a$

$u = 21 - 3a$

Question 7 Continued

$u = 11 - a \qquad u = 21 - 3a$

$11 - a = 21 - 3a$

$11 + 2a = 21$

$2a = 10$

$a = 5 \text{ ms}^{-2}$

ä/ $u = 11 - 5$

$= 6 \text{ ms}^{-1}$

(Total for Question 7 is 7 marks)

8. A bird leaves its nest at time $t = 0$ for a short flight along a straight line.

The bird then returns to its nest.

The bird is modelled as a particle moving in a straight horizontal line.

The distance, s metres, of the bird from its nest at time t seconds is given by

$$s = \frac{1}{10}(t^4 - 20t^3 + 100t^2), \text{ where } 0 \leqslant t \leqslant 10$$

(a) Explain the restriction, $0 \leqslant t \leqslant 10$

(3)

(b) Find the distance of the bird from the nest when the bird first comes to instantaneous rest.

(6)

a/ $s = \frac{1}{10}t^2(t^2 - 20t + 100)$

$= \frac{1}{10}t^2(t-10)^2$

at $t=0$ and $t=10$ $s=0$

$s > 0$ between $t=0$ and $t=10$

It represents a bird leaving the nest and returning

b/ $s = \frac{1}{10}(t^4 - 20t^3 + 100t^2)$ ↓ differentiate.

$v = \frac{1}{10}(4t^3 - 60t^2 + 200t)$

$= \frac{4}{10}(t^3 - 15t^2 + 50)$

$= \frac{2}{5}t(t^2 - 15t + 50)$

$= \frac{2}{5}t(t-5)(t-10)$

Question 8 continued

comes to rest when $\frac{2}{5}t(t-5)(t-10) = 0$

$t=0 \quad t=5 \quad t=10$

when $t=5$:

$s = \frac{1}{10}\left((5)^4 - 20(5)^3 + 100(5)^2\right)$

$= 62.5\text{m}$

(Total for Question 8 is 9 marks)

9.

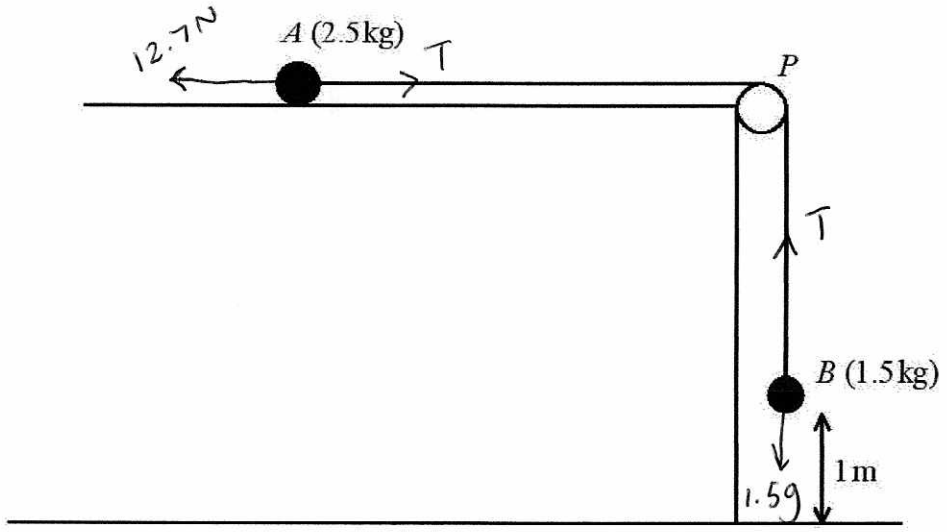


Figure 2

A small ball A of mass 2.5 kg is held at rest on a rough horizontal table.

The ball is attached to one end of a string.

The string passes over a pulley P which is fixed at the edge of the table. The other end of the string is attached to a small ball B of mass 1.5 kg hanging freely, vertically below P and with B at a height of 1 m above the horizontal floor.

The system is released from rest, with the string taut, as shown in Figure 2.

The resistance to the motion of A from the rough table is modelled as having constant magnitude 12.7 N. Ball B reaches the floor before ball A reaches the pulley.

The balls are modelled as particles, the string is modelled as being light and inextensible and the pulley is modelled as being small and smooth.

(a) (i) Write down an equation of motion for A.

(ii) Write down an equation of motion for B.

(4)

(b) Hence find the acceleration of B.

(2)

(c) Using the model, find the time it takes, from release, for B to reach the floor.

(2)

It was found that it actually took 2.3 seconds for ball B to reach the floor.

(d) Using this information

(i) comment on the appropriateness of using the model to find the time it takes ball B to reach the floor, justifying your answer.

(ii) suggest one improvement that could be made in the model.

(2)

Question 9 continued

a i/ $F = ma$

$T - 12.7 = 2.5a$

ii/ $1.5g - T = 1.5a$

b/ For A: $T = 2.5a + 12.7$

For B: $T = 1.5g - 1.5a$

$2.5a + 12.7 = 1.5g - 1.5a$

$4a = 1.5g - 12.7$

$a = \frac{1.5g - 12.7}{4}$

$= 0.5 \text{ ms}^{-2}$

c/ $s = 1$

$u = 0$

$v =$

$a = 0.5$

$t = ?$

$s = ut + \frac{1}{2}at^2$

$1 = \frac{1}{2}(0.5)t^2$

$1 = \frac{1}{4}t^2$

$4 = t^2$

$t = 2$ seconds

d/ i/ The model does not perfectly represent the situation

The resistance may be variable

The string may not be parallel to the table.

Question 9 continued

ii) A variable resistance could be included in the model