Please check the examination details below before entering your candidate information

Candidate surname	Other names

Pearson Edexcel Level 3 GCE

Centre Number	Candidate Number

Mock Paper

Paper Reference **9MA0-31**

Mathematics

Advanced

Paper 3 – Statistics & Mechanics

You must have:
Mathematical Formulae and Statistical Tables, calculator

Total Marks

Candidates may use any calculator allowed by Pearson regulations.
Calculators must not have the facility for symbolic algebra 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.
Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
Answer the questions.
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 10 questions in this question paper. The total mark for this paper is 100.
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.

SECTION A: STATISTICS

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

1. The daily mean air temperatures from the large data set, x °C, for the month of June 2015 in Jacksonville are summarised in the table below.

Daily mean air temperature (°C)	$22 \leq x < 24$	$24 \leq x < 25$	$25 \leq x < 26$	$26 \leq x < 27$	$27 \leq x < 28$	$28 \leq x < 32$
Frequency	2	5	7	4	6	6

(a) Use your calculator to estimate the mean and the standard deviation of the daily mean air temperatures from the large data set, for the month of June 2015 in Jacksonville.
Give each of your answers to 3 significant figures.

(2)

The mean and standard deviation for the daily mean air temperatures from the large data set for Perth in June 2015 are 14.8 °C and 2.37 °C respectively.

The minimum daily mean air temperature in Perth in June 2015 was 8.8 °C and the maximum daily mean air temperature was 18.5 °C.

(b) Using limits for outliers of

mean − 3 × standard deviation

mean + 3 × standard deviation

show that there are no outliers in the data for Perth in June 2015.

(2)

(c) (i) Assuming each location is typical of the hemisphere it is in, suggest what these means and standard deviations imply about the relative daily mean air temperature in June 2015 in each hemisphere. Give reasons for your answers.

(2)

(ii) Comment on the validity of the assumption in part (i).

(1)

Amy models the daily mean air temperature in summer in Jacksonville by N(27, 2.12).

A survey found that the typical British person says that 29 °C or above is ‘too hot’.

A random sample of 30 summer days in Jacksonville is taken.

(d) Use Amy’s model to predict the number of these days when the mean air temperature would be considered ‘too hot’ for a typical British person visiting Jacksonville.

(2)

2. An ornithologist believes that there is a relationship between the tail length, t mm, and the wing length, w mm, of female hook-billed kites. A random sample of size 10 is taken from a database of these kites and the relevant data is given in the table below.

***t* (mm)**	191	197	208	180	188	210	196	191	179	208
***w* (mm)**	284	285	288	273	280	283	288	271	257	289

The ornithologist plans to use a linear regression model based on these data and interpolate or extrapolate as necessary to estimate the wing length of other female hook-billed kites from their tail length.

(a) (i) Explain what is meant by extrapolation.

(1)

(ii) Explain the dangers of extrapolation.

(1)

The ornithologist attempts to calculate the product moment correlation coefficient, r, and obtains a value of 1.3.

(b) Explain how she should be able to identify that this is incorrect without carrying out any further calculations.

(1)

(c) Use your calculator to find the correct value of the product moment correlation coefficient, r.

(1)

(d) Stating your hypotheses clearly test, at the 1% significance level, whether or not there is evidence that the product moment correlation coefficient for the population is positive.

(3)

(e) Explain what your test in part (d) suggests about female hook-billed kites.

(1)

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3. A company maintains machines. It has two types of contract, a service contract and a repair contract. The company classes its customers as new customers or existing customers. The table gives information about the company's customers.

	Service contract	**Repair contract**
New customer	65	82
Existing customer	231	262

The company is going to survey its customers. It plans to take a sample of 100 of its customers, stratified by customer type and contract type.

(a) Work out how many new customers with repair contracts should be sampled.

(2)

The company has developed a test for a certain fault in the machines it services. The test sometimes gives incorrect results.

The company collects information from a sample of randomly selected machines.

- 2% of the machines have the fault
- 70% of the machines with the fault test positive for the fault
- 10% of the machines without the fault test positive for the fault.

A machine is selected at random from the sample of the machines, and tests positive for the fault.

(b) (i) Calculate the probability that the machine has the fault.

(4)

(ii) Comment on the usefulness of the company's test. Give a reason for your answer.

(1)

When the company services the machines, it checks two components, α and β, for wear and tear and replaces these if needed.

Event A is that component α needs to be replaced.
Event B is that component β needs to be replaced.

The probability that component α needs to be replaced is 0.35.
The probability that component β needs to be replaced is 0.55.
The probability that neither component needs to be replaced is 0.28.

(c) Show that events A and B are not independent.

(2)

(d) Find the probability that component α or component β needs to be replaced, but not both.

(2)

4. A company has a customer services call centre. The company believes that the time taken to complete a call to the call centre may be modelled by a normal distribution with mean 16 minutes and standard deviation σ minutes.

Given that 10% of the calls take longer than 22 minutes,

(a) show that, to 3 significant figures, the value of σ is 4.68.

(3)

(b) Calculate the percentage of calls that take less than 13 minutes.

(1)

A supervisor in the call centre claims that the mean call time is less than 16 minutes. He collects data on his own call times.

- 20% of the supervisor's calls take more than 17 minutes to complete.
- 10% of the supervisor's calls take less than 8 minutes to complete.

Assuming that the time the supervisor takes to complete a call may be modelled by a normal distribution,

(c) estimate the mean and the standard deviation of the time taken by the supervisor to complete a call.

(6)

(d) State, giving a reason, whether or not the calculations in part (c) support the supervisor's claim.

(1)

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5. A fast food company has a scratchcard competition. It has ordered scratchcards for the competition and requested that 45% of the scratchcards be winning scratchcards.

A random sample of 20 of the scratchcards is collected from each of 8 of the fast food company's stores.

(a) Assuming that 45% of the scratchcards are winning scratchcards, calculate the probability that in at least 2 of the 8 stores, 12 or more of the scratchcards are winning scratchcards.

(5)

(b) Write down 2 conditions under which the normal distribution may be used as an approximation to the binomial distribution.

(1)

A random sample of 300 of the scratchcards is taken. Assuming that 45% of all the scratchcards are winning scratchcards,

(c) use a normal approximation to find the probability that at most 122 of these 300 scratchcards are winning scratchcards.

(4)

Given that 122 of the 300 scratchcards are winning scratchcards,

(d) comment on whether or not there is evidence at the 5% significance level that the proportion of the company's scratchcards that are winning scratchcards is different from 45%.

(1)

TOTAL FOR STATISTICS IS 50 MARKS

SECTION B: MECHANICS

6. A car moves along a straight horizontal road. The car starts from rest at a fixed point A on the road and moves with constant acceleration for 30 seconds, reaching a speed of 15 m s^{-1}. This speed is then maintained.

When the car has been moving for 15 seconds a motorbike starts from rest at A and moves along the same road in the same direction as the car. The motorbike accelerates at 1.5 m s^{-2} so that it catches up with the car when the car has been moving for T seconds.

(a) Using the same axes, sketch the speed-time graph of the car and the speed-time graph of the motorbike up to the time when the motorbike catches up with the car.

(3)

(b) Find the speed of the motorbike at the instant it catches up with the car.

(6)

7.

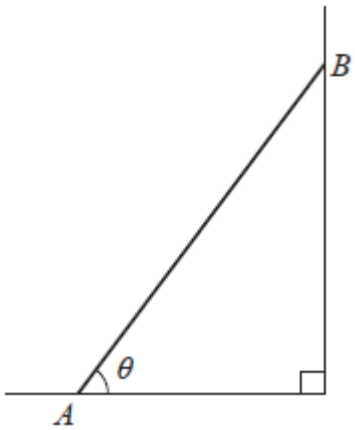

Figure 1

The ladder AB shown in Figure 1 has length $2a$ and weight W. The ladder rests in equilibrium with end A on rough horizontal ground and end B against a smooth vertical wall. The ladder rests in a vertical plane perpendicular to the wall, and is inclined at angle θ to the ground.

The coefficient of friction between the ladder and the ground is μ. The ladder is on the point of slipping. The ladder is modelled as a uniform rod.

(a) Show that $\mu = \dfrac{1}{2\tan\theta}$.

(7)

(b) If the ladder were not modelled as uniform, state how this would affect the calculated value of μ, explaining your answer carefully.

(2)

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8. [*In this question position vectors are given relative to a fixed origin O.*]

A particle P moves under the action of a single force **F** newtons. At time t seconds, where $t \geq 0$, the position vector of P, **r** metres, is given by

$$\mathbf{r} = (t^3 - 5t)\mathbf{i} + (5t^2 + 6t)\mathbf{j}.$$

The mass of P is 0.5 kg.

At time T seconds, P is moving in the direction of the vector $(\mathbf{i} + 2\mathbf{j})$.

(a) Find the value of T.

(5)

(b) Find the magnitude of **F** when $t = 2$.

(4)

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4. [*In this question the unit vectors* **i** *and* **j** *are in a vertical plane,* **i** *being horizontal and* **j** *being vertically upward.*]

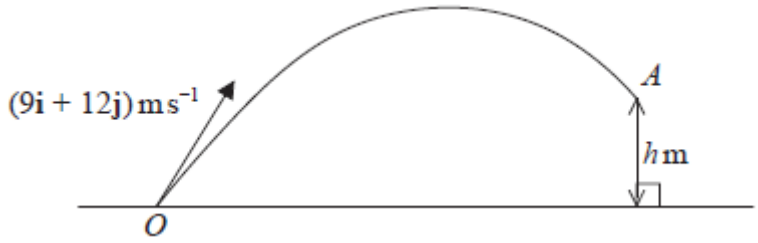

Figure 2

A small ball is projected from the fixed point O on horizontal ground with velocity $(9\mathbf{i} + 12\mathbf{j})$ m s^{-1}. The ball passes through the point A which is h metres vertically above the level of O, as shown in Figure 2. The velocity of the ball at the instant it passes through the point A is $\lambda(\mathbf{i} - \mathbf{j})$ m s^{-1}, where λ is a positive constant. The ball is modelled as a particle moving freely under gravity.

(a) Find the value of h.

(4)

(b) State the minimum speed of the ball as it moves from O to A.

(1)

(c) Find the length of time for which the speed of the ball is less than 12 m s^{-1}.

(4)

The model could be refined by considering air resistance.

(d) Suggest one other refinement to the model that would make it more realistic.

(1)

5.

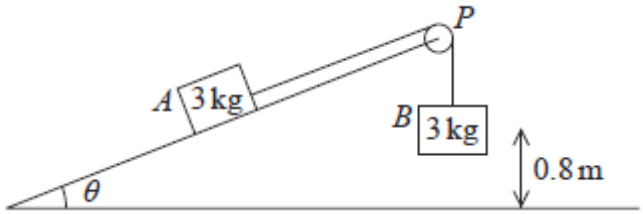

Figure 3

Two packages A and B, each of mass 3 kg, are attached to the ends of a rope. Initially A is held at rest on a smooth fixed plane that is inclined at angle θ to the horizontal ground, where $\sin\theta = \frac{2}{7}$.

The rope passes over a pulley, P, fixed at the top of the plane. The pulley is modelled as small and smooth. The part of the string from A to P is parallel to a line of greatest slope of the plane. Package B hangs freely below P, as shown in Figure 3.

The packages are released from rest with the string taut and A moves up the plane. In this model, the packages are modelled as particles and the rope as a light inextensible string. The magnitude of the tension in the string immediately after the packages are released is T newtons.

(a) Find the value of T.

(6)

At the instant when the packages are released from rest, B is 0.8 m above the ground and A is at the point C on the plane. When B reaches the ground, B is immediately brought to rest by the impact with the ground. In the subsequent motion, A does not reach P and comes to instantaneous rest at the point D on the plane.

(b) Find the distance CD.

(5)

(c) State two limitations of the model that could affect the reliability of your answers.

(2)

TOTAL FOR MECHANICS IS 50 MARKS

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