LSE – Undergraduate Admissions Assessment

Mathematics – Section B

Give all numerical answers to 3 sf. You are expected to type out your answers onto the computer. Use of mathematical typing software is not required so expressions such as 1.5^4 can be written as 1.5^4. You **do not** need to type out all stages of your answer just the key parts and the calculation that you have done to get to your answer. Intermediate working can be completed on paper which will **not be marked**. You should **use a scientific calculator,** but your method must be clear.

Paper C Total = 100 marks

1.

A country is planning to reduce its CO_2 (carbon dioxide) emissions by using Biofuels (fuel made from plants) instead of Diesel in vehicles.

Using Diesel as a fuel produces 84 g of CO_2 emissions per megajoule (MJ) of energy produced. A megajoule is 1 million Joules.

The table shows the CO_2 emissions in grams per megajoule of energy for four biofuels

Biofuel	**CO_2 emissions per megajoule of energy (g)**
Soybean	45
Palm Oil	30
Corn	60
Sugar Cane	25

a) Which biofuel gives the lowest CO_2 emissions per megajoule?

1 mark

b) Compared with using Diesel which of the biofuels would cut the CO_2 emissions by more than 50%?

2 marks

c) What is the percentage reduction in using Soybean as a fuel rather than Diesel?

2 marks

d) A coach needs roughly 1300 MJ to travel 100km. The distance between two major cities is 662km.

Based on the data given what would the CO_2 emissions be for the coach to travel between these two cities using

i) Diesel fuel

ii) Palm Oil Fuel

3 marks

d) In order to get the land needed to grow the crops for the Biofuels the country needs to consider whether forest will be cut down.

The table below shows the CO_2 emissions and percentage increase in emissions of CO_2 for each crop caused by cutting down forest to grow the crop.

Biofuel	**CO_2 emissions if forest is *not* cut down (g)**	**CO_2 emissions if forest is cut down (g)**	**Percentage increase in CO_2 emissions %**
Soybean	45	***e) ii)***	300
Palm Oil	30	125	***e) iii)***
Corn	60	75	***e) iv)***
Sugar Cane	25	65	160

e) i) For Sugar Cane the CO_2 emissions increase from 25g to 65g which is a 160% increase. Write down a suitable calculation to confirm that the increase is 160%

ii) Calculate the CO_2 emissions for using Soybean as a biofuel when forests are cut down.

iii) Calculate the percentage increase in emissions when using Palm Oil.

iv) Calculate the percentage increase in emissions when using Corn.

8 marks

f) Which fuel gives the lowest CO_2 emissions if forest is cut down?

1 mark

g) In practice some diesel is mixed with the Biofuel and currently the ratio of Diesel to Biofuel is 7:3 but the country is intending to lower the proportion of Diesel to a 1:1 ratio by 2025. Calculate the CO_2 emissions per MJ when Diesel is mixed with sugar cane as the Biofuel if forest is cut down.

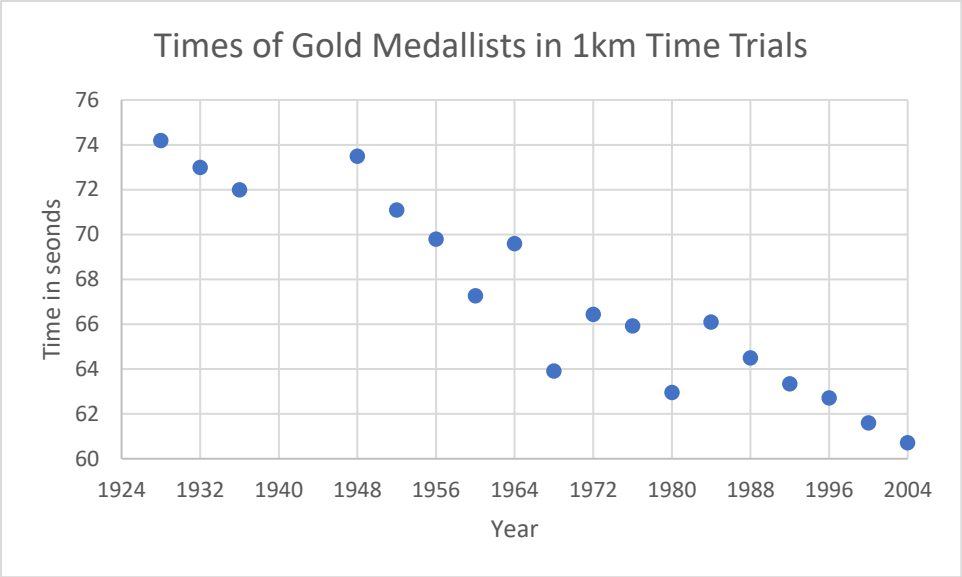
i) with the current ratio.

ii) with the ratio planned for 2025. 5 marks

Total 22 marks

2. Alex enjoys cycling and was researching Olympic events. Alex discovered that the 1km time trial was discontinued in 2004 to make space for more BMX events.

He produced a graph for the times for each of the gold medallists.



a) i) Describe the general trend seen in the graph.

ii) Give two possible reasons for this trend

iii) What was the approximate time in 1980?

iv) Which year was the time closest to 1 minute 10 seconds?

5 marks

b) i) The Olympics normally occurs every 4 years. During the second world war the event did not happen. In which years did the Olympics not happen on this 4 year schedule?

ii) What happened to the gold medal time in the first games after the war compared with before the war and suggest a reason for this.

4 marks

c) Alex wants to predict the Gold medal times if the event had continued.

i) Work out the gradient of the line joining the first and last data points with times of 74.2 seconds and 60.711 seconds respectively giving your answer to 4 sf.

ii) Hence or otherwise work out the equation of the line joining the first and last data points.

Give your answer in the form $y = mx + c$ giving m and c to 4 sf.

iii) Alex calculates the line of best fit as $\boldsymbol{y = -0.1752x + 412.0}$. Give a reason why your equation in c)ii) is different from the one that Alex calculated.

6 marks

d) i) Assuming the next Olympics happens on schedule in 2024 use Alex's equation from ciii) to predict the Gold Medal time at these Olympics.

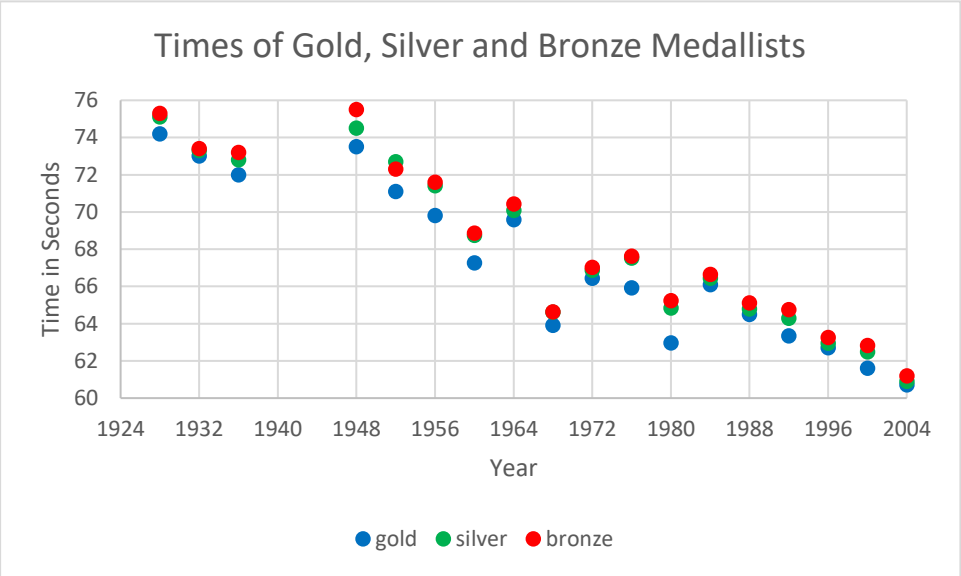
ii) Use your answer to d)i) to predict the average speed in ***km per hour*** at the next Olympics.

iii) Comment on how realistic you think this speed is.

iv) Use Alex's equation in ciii) to work out in which year the time given by the equation is first faster than 1 minute.

9 marks

d) Alex decides to compare the Gold medal times with the times for Bronze and Silver



medallists and produces this graph.

i) Alex thinks that the times of all the medallists are getting closer together. Looking at Alex's graph would you agree? Give a reason for your answer.

ii) Alex works out the equations of the lines of best fit for Bronze and Silver as

$y = -0.1792x + 421.0$ and $y = -0.1804x + 423.2$ respectively.

Using the equations above and Alex's equation from ciii) to find the year in which the equations for the gold and bronze medallists give the same time.

iii) Use your answer in d ii) to find the corresponding times of all 3 medallists. Comment on your answer.

7 marks

Total 31 marks

3. In July 2017 a large chunk of the Larson C Ice shelf in Antarctica broke off to form a massive iceberg which was designated A–68.

a) A-68 initially had a top surface area of 5 800 km^2 and was one of the largest recorded icebergs.

i) The largest recorded iceberg was B-15 which had a surface area that was 90% larger than A-68. Calculate the surface area of B–15

ii) A-68 reduced the surface area of the Larson C Ice shelf by 2%. Calculate the surface area of the Larson C Ice shelf after A-68 had broken off.

5 marks

b) As A-68 drifted into warmer waters large chunks of ice broke off.

i) The first large chunk broke off in 2018/2019. This chunk measured 14km by 8km. Assuming an approximately rectangular shape what area of A-68 was left after it broke off?

ii) The next large chunk that broke off in April 2020 had an area of 175 km^2. What percentage of the original iceberg remained just after this happened?

4 marks

c) A-68 continued to break up and by April 2021 the largest part was only 5.5 km long. By the end of 2021 all the ice had melted.

i) A- 68 was 200 m thick. Assuming this thickness was constant find the original volume of A-68 in m^3.

ii) The density of ice is 916.7 kg per m^3. Use your answer to c)i) to calculate the original mass of A-68 in kg.

iii) Ice is less dense than water. The density of fresh water is 1000 kg per m^3. Use your answer to c)ii) to find the volume of fresh water that A-68 would become.

6 marks

d) At the maximum rate of melting A-68 was dumping 1.5 billion tonnes of fresh water into the ocean per day. (1 tonne = 1 000 kg).

Use your answer to c)ii) to calculate how many days A-68 would have taken to melt at this rate.

2 marks

e) The average UK citizen uses 152 litres of water a day.

i) What is 152 litres in cm^3?

ii) 1 cm^3 of water has mass 1g. How many kg of water per day does the average UK citizen use?

iii) The current population of the UK is about 68 million. How many tonnes of water is used per day by the UK citizens?

iv) Does your answer to e)iii) confirm the claim that at is maximum rate of melting A-68 was dumping about 150 times the amount of water used daily by everyone in the UK. Give a numerical reason for your answer.

8 marks

Total 25 marks

4. When a golf ball is hit it follows a curved path until it lands.

The horizontal distance that it travels before it lands can be given by a formula that depends on the speed it is hit at and the angle with the ground of the initial hit by the golf club.

The formula for the maximum distance, d, when the angle is $45°$ is given by $d = \frac{v^2}{g}$ where v is the initial speed in m/s and g is the acceleration due to gravity. This formula assumes that there is no wind or air resistance and that the ground is at the same level.

a) The average female golfer hits the ball with a speed of 111 miles per hour (mph).

i) Using $1\ mile\ =\ 1610\ m$ change $111\ mph$ to m/s

ii) Assuming that the ball is hit at an angle of $45°$ find the maximum distance in metres travelled by a ball hit at $111\ mph$. Use $g = 9.81\ m/s^2$

iii) A good female golfer can reach speeds 13% higher than average. What would be the maximum distance that such a golfer could hit the ball?

iv) Different golf clubs can achieve different speeds. What is the difference for the maximum distance travelled for a Driver hitting at 74 m/s compared with a Pitching Wedge at 45 m/s?

10 marks

b) In practice balls are hit at different angles.

The formula for the distance travelled if the ball is hit at 30^o is $d = \frac{\sqrt{3}v^2}{2g}$.

How much further can an average male golfer hitting at a speed of $59\ m/s$ achieve when hitting at an angle of 45^o compared with an angle of 30^o? *3 marks*

c) A golf course has a distance between where the golf ball is hit and the hole of $250m$. At what speed must the ball be hit at to travel this distance of $250m$

i) when hit at an angle 45^o

ii) when hit at an angle 30^o *6 marks*

d) The times of flight, T, for 45^o and 30^o are given by $T = \frac{\sqrt{2}v}{g}$ and $T = \frac{v}{g}$ respectively.

Use your answers to c) to find the difference in times of flight to travel $250\ m$ at 45^o and 30^o. *3 marks*

Total 22 marks