A Level · Edexcel · Maths

4 hours 41 questions

2.12 Modelling with Functions

2.12.1 Modelling with Functions

Easy (9 questions)	/42
Medium (11 questions)	/68
Hard (11 questions)	/66
Very Hard (10 questions)	/62
Total Marks	**/238**

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Easy Questions

1 In football's Premier League a team is awarded 3 points for each match they win, 1 point for each drawn match and no points for a loss.

(i) Using W for the number of matches won, D for the number of matches drawn, and P for the total number of points a team has, write down a formula for P in terms of W and D.

(ii) Briefly explain why there is no need to use L in the formula above for the number of matches lost.

(2 marks)

2 (a) Water is leaking from a pipe. The rate of the leak is directly proportional to the speed of water flowing through the pipe.

It was observed that the rate of the leak was 4 litres per second, ls^{-1} when the speed of water flowing through the pipe was 2 metres per second, ms^{-1}.

Find a formula linking the rate of the leak, $L\ \text{ls}^{-1}$ to the speed of water flowing through the pipe, $\text{s}\ \text{ms}^{-1}$.

(3 marks)

(b) (i) Find the rate of the leak if the speed of water is $2.5\ \text{ms}^{-1}$.

(ii) Find the speed of water if the rate of the leak is $3\ \text{ls}^{-1}$.

(3 marks)

3 A soft ball is thrown upwards from the top of a building.
The height, h m of the ball above the ground after t seconds is modelled by the function

$$h(t) = 12 + 20t - 5t^2 \qquad t \geq 0$$

(i) Evaluate $h(0)$ and hence deduce the height of the building.

(ii) Find the height of the ball after 4 seconds.

(4 marks)

4 The number of cases of an unknown virus are modelled by the formula

$$V = \frac{2700}{(d-30)^2} \qquad 0 \leq d < 30$$

where d is the number of days after the virus was first discovered and V is the total number of cases to date.

(i) Find the number of cases when the virus was first discovered.

(ii) Sketch a graph of V against d labelling the coordinates of the point where the graph intersects the V-axis.

(4 marks)

5 (a) The number of toys, P, produced by a machine in one hour is modelled by the function

$$P(T) = (20 - T)(T - 40) \qquad 20 \leq T \leq 40$$

where $T\,°C$ is the temperature of the machine.

Find the number of toys produced in one hour when the temperature of the machine is $25\,°C$.

(1 mark)

(b) (i) Show that $P(T) = 60T - T^2 - 800$.

(ii) By completing the square show further that $P(T) = 100 - (T - 30)^2$.

(iii) Using your answer from (ii) or otherwise, find the temperature at which the machine is at its most productive, and how many toys it produces in one hour at this temperature.

(6 marks)

6 A patient takes a new medication at midday. The amount of drug, D mg, remaining in their bloodstream hours after midday is modelled by the formula

$$D(h) = 1 + 6h - h^2 \qquad 0 \leq h \leq 6$$

(i) Evaluate $D(0)$ and deduce the amount of drug in the patient's bloodstream before they take any medication.

(ii) Find the amount of drug in the patient's bloodstream at 2 pm.

(iii) Show that by 6pm the amount of drug in the patient's bloodstream has returned to its starting amount.

(6 marks)

7 (a) A company selling books models the number of books sold per year, N, using the formula

$$N = 10\,000 - 200c$$

where c is the price per book in pounds sterling.

(i) Find the number of books the company can expect to sell if they are priced at £18 each?

(ii) Work out the total income the company will receive if they sell all books at £18 each.

(2 marks)

(b) Find the number of books the company can expect to sell if they are priced at £16 each and work out the total income the company will receive if they sell all books at this price.

(2 marks)

(c) What do your answers to part (a) and (b) suggest about the relationship between the price of a book, the number sold and the total income received?

(1 mark)

8 (a) A cricket ball is projected directly upwards from ground level.

The motion of the cricket ball is modelled by the function

$$h(t) = 20t - 5t^2 \qquad t > 0$$

where h metres is the height of the cricket ball above ground level after t seconds.

(i) Factorise $h(t)$.

(ii) Hence, find the time at which the cricket ball returns to ground level.

(2 marks)

(b) The motion of a second cricket ball is modelled by a similar function

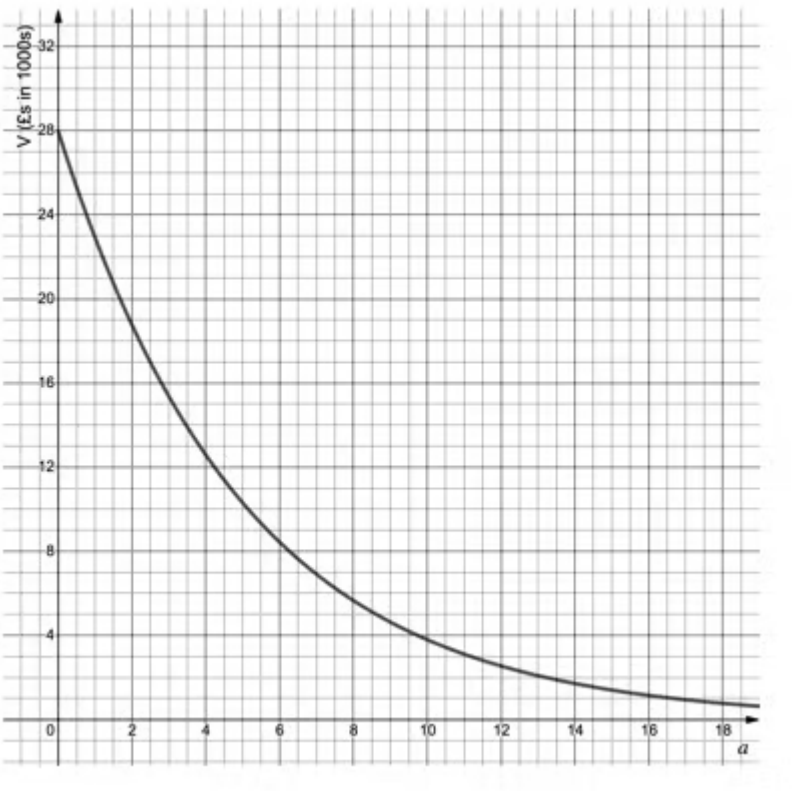
$$d(t) = 16t - 5t^2 \qquad t > 0$$

where d metres is the height of the cricket ball above ground level after t seconds.

Find the times at which this cricket ball is exactly 3 metres above the ground.

(3 marks)

9 The graph below shows a suggested model for estimating the value of a brand-new car costing £28 000. a is the car's age in years and £V is the car's value in thousands.



(i) Use the model to predict a car's value after 8 years.

(ii) Use the model to predict how long it takes a brand-new car to halve in value.

(iii) This model predicts that regardless of how old a car is, it's value never reaches £0. Suggest a reason to justify this property of the model.

(3 marks)

Medium Questions

1 (a) It has often been said, to avoid relegation from football's Premier League, teams should aim to score at least 40 points in a season. Each team plays 38 games, a win is rewarded with 3 points and a draw with 1 point. No points are awarded for a loss.

Using W and D as the number of wins and draws respectively, write down an inequality describing the number of points a team should aim for to avoid relegation.

(2 marks)

(b) Another condition on W and D is $W+D\leq 38$.

(i) Briefly explain why this second condition arises.

(ii) Explain why $W\geq 0$ and $D\geq 0$ must also be conditions.

(2 marks)

(c) A team has won 3 games and drawn 5 after playing 19 games.
Write down an updated inequality for the number of points required during the remainder of the season in order to avoid relegation.

(2 marks)

2 (a) The leakage rate of water from a pipe, $L\ 1\ \mathrm{s}^{-1}$ (litres per second), is directly proportional to flow rate, $\mathrm{s}\ \mathrm{m}\ \mathrm{s}^{-1}$ (meters per second), which is the speed of the water flowing through the pipe.
It was observed that the leakage rate was $0.31\ \mathrm{s}^{-1}$ when the flow rate was $0.6\ \mathrm{m}\ \mathrm{s}^{-1}$.

Show that the constant of proportionality is 0.5 and hence write down an equation connecting L and s.

(2 marks)

(b) Find the leakage rate when the flow rate is $1.8\ \mathrm{m}\ \mathrm{s}^{-1}$.

(2 marks)

(c) The flow rate is reduced should the leakage rate exceed $0.8\ l\ s^{-1}$.
Find the maximum possible flow rate before it is reduced.

(2 marks)

3 (a) A soft ball is thrown upwards from the top of a 10 m tall building.
The height, h m of the ball above the ground after t seconds is modelled by the function

$$h(t) = H + 7.8t - 4.9t^2 \qquad t > 0$$

Write down the value of H.

(1 mark)

(b) Find the height of the ball after 2 seconds.

(2 marks)

(c) At what time is the ball at the same height as it was when thrown?

(2 marks)

(d) How long does it take for the ball to first hit the ground?

(2 marks)

4 (a) The number of cases of an unknown virus are modelled by the formula

$$V = \frac{225}{(d-15)^2} \qquad 0 \leq d < 15$$

where d is the number of days after the first case was discovered and V is the total number of cases to date.

Find the number of cases after 10 days.

(2 marks)

(b) Sketch a graph of V against d, clearly marking the coordinate where the graph intersects the V-axis.

(2 marks)

(c) A politician says that after 5 days there were 2.25 cases of the virus.
Comment on the politician's statement.

(1 mark)

5 (a) A machine produces toys at a rate dependent on the machine's temperature. The more extreme the temperature of the machine, the less productive it is.

The productivity of the machine is measured by

$$P(T) = 0.02T(5 - T)(T - 60) \qquad 5 \leq T \leq 60$$

where P is the number of toys produced per hour and $T\,°C$ is the temperature of the machine.

Find the number of toys produced per hour when the temperature of the machine is $36\,°C$.

(1 mark)

(b) Show that $P(T) = 1.3T^2 - 0.02T^3 - 6T$.

(2 marks)

(c) Find the temperatures at which productivity is 80 toys per hour.

(2 marks)

(d) Productivity is at its peak when the temperature of the machine is $41\,°C$.
Find the number of toys produced per hour at this temperature.

(1 mark)

(e) Suggest a reason why the machine cannot operate below $5\,°C$.

(1 mark)

6 (a) A patient takes a new medication at midday. The amount of drug, D mg, remaining in their bloodstream h hours after midday is modelled by the formula

$$D = 0.04 + 0.16h - 0.04h^2 \qquad 0 \leq h \leq 4$$

What amount of drug is already naturally occurring in the patient's bloodstream before taking any medication?

(1 mark)

(b) Without doing any calculations, explain how you can tell that the time the drug reaches its highest level is after 2 hours, at 2 pm.

(2 marks)

(c) It is safe for the patient to take more medication once the amount of drug in their bloodstream falls below 0.16 mg. When is the earliest time the patient can take a second dose of the medication?

(2 marks)

(d) At what time does the amount of drug in the patient's bloodstream return to its natural level?

(1 mark)

7 (a) Last year, a company sold 10 000 books, at a price of £20 each.

The previous year, the company sold 10 250 books at a price of £19 each.

The company wants to increase the price again this year and uses the formula $N = a + bc$ to model the number of books sold annually. Where N is the number of books sold, c is the selling price of the book and a and b are constants.

Write down two equations for the sales from the past two years and hence find the constants a and b.

(2 marks)

(b) Write down the model for the number of books sold annually.

(1 mark)

(c) This year the company intends raising the price of the book by £2.

(i) How many books should the company expect to sell this year?

(ii) Calculate the income the company should expect from book sales this year.

(2 marks)

(d) Work out the book sale income for last year and the year before.

(2 marks)

(e) Briefly comment on the relationship between number of books sold and the income for this three-year period.

(2 marks)

8 (a) A cricket ball is projected directly upwards from ground level. The motion of the cricket ball is modelled by the function

$$h(t) = 13t - 4.9t^2 \qquad t > 0$$

where h metres is the height of the cricket ball above ground level after t seconds.

Find the times at which the cricket ball is exactly 3 m above the ground.

(2 marks)

(b) For how long is the cricket ball at least 3 m above the ground?

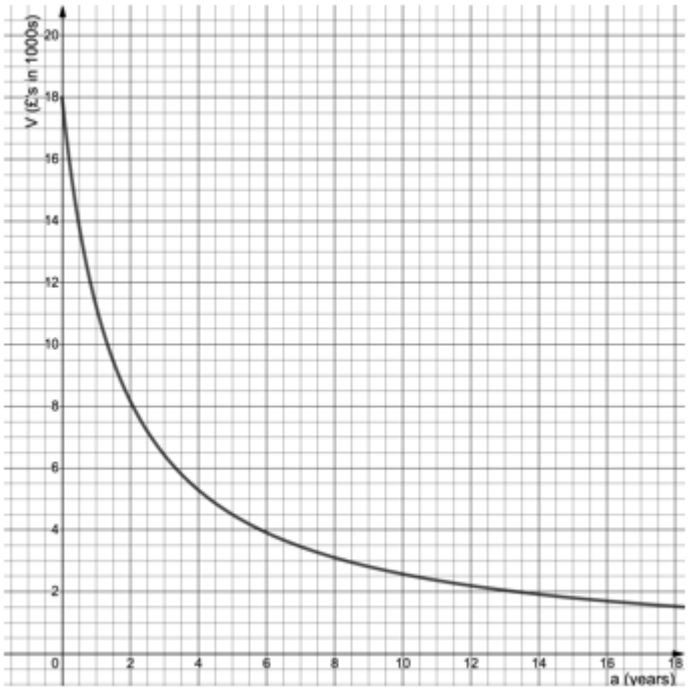
(1 mark)

(c) A player catches the cricket ball (on its way down) at a height of 0.8 m above the ground.

How long was the cricket ball in the air for?

(2 marks)

9 (a) The graph below shows a suggested model for estimating the value of a brand new car costing £18 000. a is the car's age in years and £V is the car's value in thousands.



Use the model to predict a car's value after 5 years.

(1 mark)

(b) A car (of the same make and model) is seen advertised for sale at £3250.
How old would you expect the car to be?

(1 mark)

(c) In terms of its value, what does the model suggest is a disadvantage of buying a brand new car?

(1 mark)

(d) A 16 year old car was scrapped, and the owner received £200 for spare parts.
State a problem with using this model for very old cars.

(1 mark)

10 (a) A fountain is designed so that water is projected over a walk way. The path of the water is modelled by the formula

$$y = x(4 - x) \quad 0 \leq x \leq 4$$

where x is the horizontal distance in meters from the base of the fountain at ground level and y is the height of the water in metres.

Sketch a graph of the model, labelling any intersections with the coordinate axes.

(1 mark)

(b) Find the height of the water at a ground width of 1.3 m.

(2 marks)

(c) The average person is 1.7 m tall and needs a ground width of 1.2 m in order to walk comfortably.

Find the distance at ground level between the two points where the water height is 1.7 m.

(2 marks)

(d) Use your answer to part (c) to work out the maximum number of average sized people that can comfortably walk under the fountain side by side without getting wet.

(1 mark)

11 (a) A manufacturer claims their kettle will keep boiled water hot enough to make a cup of tea for half an hour.

The kettle "boils" water to $90\,°C$ before switching off.

Tea needs to be made with water of a temperature above $77\,°C$.

A linear model of the temperature, $T\,°C$, of the water inside the kettle t minutes after the kettle boils is of the form

$$T = 90 - bt$$

where b is a constant.

Explain the significance of the number 90 in the model.

(1 mark)

(b) Assuming the temperature of the water is $77\,°C$ half an hour precisely after the kettle boils, find the value of b.

(2 marks)

(c) Find the time at which the temperature has dropped by $2\,°C$.

(2 marks)

(d) A specialist tea website claims that the perfect cup of tea should be made with water at a temperature of no higher than $85\,°C$.
How many minutes (after the kettle boils) should a user wait before attempting to make the perfect cup of tea?

(1 mark)

(e) Explain why the model is redundant for values of t greater than 30.

(1 mark)

Hard Questions

1 (a) It has often been said, to avoid relegation from football's Premier League, teams should aim to score at least 40 points in a season. Each team plays 38 games, a win is rewarded with 3 points and a draw with 1 point. No points are awarded for a loss.

Using W and D as the number of wins and draws respectively, write down two inequalities. One relating to the number of points a team needs to avoid relegation and one relating to the number of games played.

(2 marks)

(b) Explain why $W \geq 0$ and $D \geq 0$ must also be conditions related to the problem.

(1 mark)

(c) A team has won 4 games and drawn 4 after playing 17 games.
Write down two updated inequalities for the number of wins and draws required for the remainder of the season in order to avoid relegation.

(2 marks)

2 (a) The leakage rate of water from a pipe, L $\mathrm{l\ s^{-1}}$ (litres per second), is directly proportional to the square root of the flow rate, $\mathrm{s\ m\ s^{-1}}$ (meters per second), which is the speed of the water flowing through the pipe.
It was observed that the leaking rate was $0.72\ \mathrm{l\ s^{-1}}$ when the flow rate was $0.64\ \mathrm{m\ s^{-1}}$

Write down an equation connecting L and S.

(2 marks)

(b) Find the flow rate when the leakage rate is $0.49\ \mathrm{l\ s^{-1}}$.

(2 marks)

(c) An alternative model for the leakage rate is $L = 0.5\mathrm{s}$.
Apart from when there is no leak find a flow rate and a leakage rate for when both models predict the same result.

(2 marks)

3 (a) A soft ball is thrown upwards from the top of a building.
The height, h m of the ball above the ground after t seconds is modelled by the function

$$h(t) = 15 + 8.4t - 4.9t^2 \qquad t > 0$$

What is the significance of the constant 15 in the function?

(1 mark)

(b) At what time is the ball at the same height as when it was thrown?

(2 marks)

(c) Find the time at which the ball is at its maximum height and what this maximum height is.

(3 marks)

(d) How long does it take for the ball to first hit the ground?

(2 marks)

(e) Given that the ball first hits the ground at a distance 20 m from the base of the building find the shortest distance between this point and where the ball was thrown from.

(2 marks)

4 (a) The number of cases of an unknown virus are modelled by the formula

$$V = \frac{400}{(d-20)^2} \qquad 0 \leq d < 20$$

where d is the number of days after the first case was discovered and V is the total number of cases to date.

Find the number of cases after 10 days and after 15 days.

(2 marks)

(b) Sketch a graph of V against d, clearly marking the coordinate where the graph intersects the V-axis.

(2 marks)

(c) Scientists suggest the model is not accurate beyond 15 days.
Suggest a reason why.

(1 mark)

5 (a) A machine produces toys at a rate dependent on the machine's temperature. The more extreme the temperature of the machine, the less productive it is.

The productivity of the machine is measured by

$$P(T) = 0.015\,T(22 - T)(T - 75) \qquad 22 \leq T \leq 75$$

where P is the number of toys produced per hour and $T\,°C$ is the temperature of the machine.

Suggest a reason why the machine only operates between $22\,°C$ and $75\,°C$.

(1 mark)

(b) Productivity is at its peak when the machine is producing around 544 toys per hour. Find the approximate temperature of the machine at this rate of production.

(3 marks)

(c) The temperature of the machine rises by $7\,°C$ for every hour it is in constant use. In order to prevent a breakdown the machine is switched off once the temperature exceeds $60.5\,°C$.

Assuming the machine is at $22\,°C$ when it is switched on, find the number of hours it can run continuously for, before having to be being switched off.

(2 marks)

6 (a) A patient takes some medication at midday. The amount of drug, D mg, remaining in their bloodstream h hours after midday is modelled by the formula

$$D = 0.03 + 0.25h - 0.05h^2 \qquad 0 \leq h \leq 5$$

What amount of drug is already naturally occurring in the patient's bloodstream before taking any medication?

(1 mark)

(b) After what time does the amount of drug in the patient's bloodstream return to its natural level?

(2 marks)

(c) It is safe for the patient to take more medication once the amount of drug in their bloodstream falls below 0.23 mg. When is the earliest a patient can take a second dose of the medication?

(2 marks)

(d) Explain why your answer to part (c) should not be 1pm despite this being a solution to the relevant equation?

(1 mark)

7 (a) Last year, a company sold 12 000 copies of a book, at a price of £15 each.

This year, the company wants to increase the price of the book and predicts that for every £2 increase in price, annual sales will drop by 400 books.

The formula $N = a + bc$ is used to model the number of books sold annually. Where N is the number of books sold, c is the selling price of the book and a and b are constants.

Using the company's prediction regarding the expected impact of price increases, write down another equation involving N, a, b and c

(1 mark)

(b) Find the values of a and b.

(2 marks)

(c) Hence write down the model used for the number of books sold annually.

(1 mark)

(d) The income, £I, the company generates from sales of the book is given by

$$I = c(a + bc)$$

where a and b take the same values as in part (b).

Find the price the company should charge per book in order to maximise their income.

(2 marks)

8 (a) A slow-motion camera is used to record the motion of a cricket ball projected directly upwards from ground level. The motion of the cricket ball is modelled by the function

$$h(t) = 11t - 4.9t^2 \qquad t > 0$$

where h metres is the height of the cricket ball above ground level after t seconds. The camera will capture the cricket balls' motion whilst it remains at least 3 m above ground level.

Find the maximum height the cricket ball reaches and how long it takes to reach this point.

(2 marks)

(b) Find the length of time for which the camera will capture the cricket ball's motion.

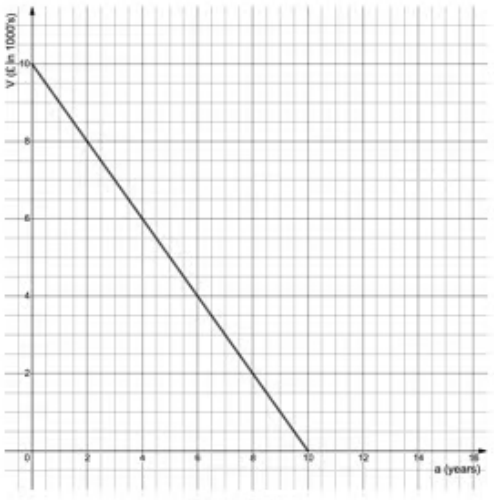
(3 marks)

(c) The slow-motion camera slows real-time down 200 times. So, 1 second of real-time recorded footage would be 200 seconds of slow-motion footage.

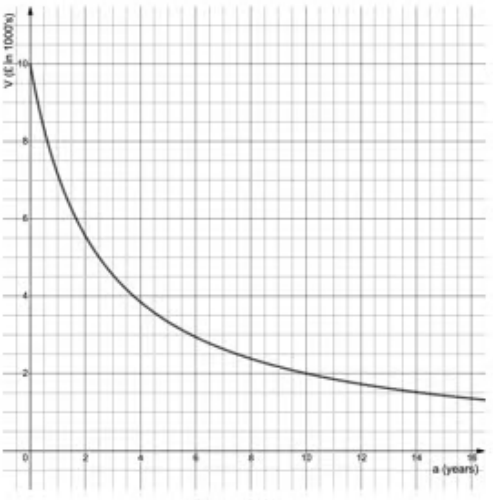
How many seconds of slow-motion cricket ball footage will the camera capture?

(1 mark)

9 (a) The graphs below show two different suggested models for estimating the value of a brand-new car costing £10 000. a is the car's age in years and £V is the car's value in thousands



Model 1



Model 2

Other than when brand new, at what age do the two models predict the same value for the car?

(1 mark)

(b) At what age does Model 1 predict the car will become worthless?

(1 mark)

(c) State a problem with using Model 1 for older cars.

(1 mark)

(d) State a problem with using Model 2 for very old cars.

(1 mark)

(e) Compare the two models for estimating a car's value at 8 years old and higher. Suggest which model you think is more realistic, justifying your answer.

(2 marks)

10 (a) A fountain is designed so that water is projected over a walkway. The path of the water is modelled by the formula

$$y = x(5 - x) \quad 0 \leq x \leq 5$$

where x is the horizontal distance in meters from the base of the fountain at ground level and y is the height of the water in metres.

Sketch the graph of the model, labelling any intersections with the coordinate axes.

(2 marks)

(b) The average person is 1.7 m tall and needs a ground width of 1.2 m in order to walk comfortably.

Work out the maximum number of average sized people that can comfortably walk under the fountain side by side without getting wet.

(3 marks)

11 (a) A manufacturer claims their flask will keep a hot drink warm for up to 8 hours.

In this sense, warm is considered to be $40°C$ or higher.

It is assumed a hot drink has an initial temperature of $.80°C$

A linear model of the temperature, $T°C$, inside the flask hours from when a hot drink is first made is of the form

$$T = a + bt$$

where a and b are constants.

Write down the value of a.

(1 mark)

(b) Assuming that a hot drink has a temperature of $40°C$ after 8 hours, find the value of b.

(2 marks)

(c) When does the model predict the temperature has decreased by $20°C$.

(1 mark)

(d) Suggest a problem if the model were to be used for values of t larger than 8.

(1 mark)

Very Hard Questions

1 (a) It has often been said, to avoid relegation from football's Premier League, teams should aim to score at least 40 points in a season. Each team plays 38 games, a win is rewarded with 3 points and a draw with 1 point. No points are awarded for a loss.

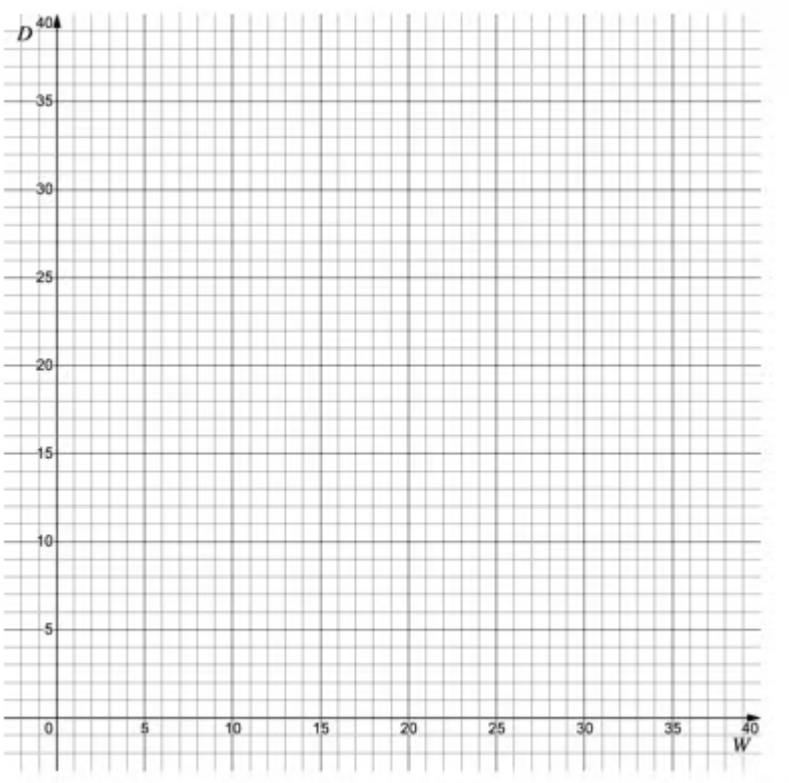
Using W and D as the number of wins and draws respectively, write down two inequalities. One relating to the number of points a team needs to avoid relegation and one relating to the number of games played.

(2 marks)

(b) Explain why $W \geq 0$ and $D \geq 0$ must also be conditions related to the problem.

(1 mark)

(c) On the axes below, display all the inequalities from parts (a) and (b).



(2 marks)

(d) Using your graph, or otherwise, determine the minimum number of games a team can win and still avoid relegation. Justify your answer by showing how the team can still accumulate at least 40 points.

(1 mark)

2 (a) The leakage rate of water from a pipe, $L \text{ l s}^{-1}$ (litres per second), is directly proportional to the cube root of the flow rate, $s \text{ m s}^{-1}$ (meters per second), which is the speed of the water flowing through the pipe.
It was observed that the leakage rate was 0.63 l s^{-1} when the flow rate was 0.729 m s^{-1}.

Find the flow rate when the leakage rate is 0.21 l s^{-1}.

(4 marks)

(b) An alternative model for the leakage rate is $L = 0.4s$.
Apart from when there is no leak find a flow rate and a leakage rate for when both models predict the same result.

(2 marks)

3 (a) A soft ball is thrown upwards from the top of a building.
The height, h m of the ball above the ground after t seconds is modelled by the function

$$h(t) = H + 9.8t - 4.9t^2 \qquad t > 0$$

What does the constant H indicate in the function?

(1 mark)

(b) At what time is the ball at the same height as when it was thrown?

(2 marks)

(c) Find in terms of H, how long it takes for the ball to first hit the ground.

(2 marks)

(d) How much longer does a ball launched from a 25 m tall building stay in the air for compared to a ball launched from a 15 m tall building?

(2 marks)

4 (a) The number of cases of an unknown virus are modelled by the formula

$$V = \frac{625}{(d-25)^2} \qquad 0 \leq d < 25$$

where d is the number of days after the first case was discovered and V is the total number of cases to date.

Sketch a graph of V against d, clearly marking the coordinate where the graph intersects the V-axis.

(2 marks)

(b) Explain why the model is not appropriate for $d \geq 25$.

(1 mark)

(c) Scientists suggest the model is not accurate after 18 days.
Suggest a reason why.

(1 mark)

(d) The model is a graph transformation of the graph with equation $y = \frac{a}{x^2}$, where $a = 625$.

Describe this transformation.

(2 marks)

5 (a) A machine produces toys at a rate dependent on the machine's temperature. The more extreme the temperature of the machine, the less productive it is.

The productivity of the machine is measured by

$$P(T) = 0.01T(22 - T)(T - 60) \qquad 22 \leq T \leq 60$$

where P is the number of toys produced per hour and $T\,°C$ is the temperature of the machine.

Suggest a reason for the temperature condition $22 \leq T \leq 60$.

(1 mark)

(b) Sketch the graph of the machine's productivity for $22 \leq T \leq 60$.

(2 marks)

(c) Using your graph to estimate the temperature at which productivity is at its peak, calculate the number of toys produced at this temperature.

(2 marks)

(d) The temperature of the machine rises by 6 °C for every hour it is in constant use.
In order to prevent a breakdown the machine is switched off once the temperature exceeds 52 °C.

(i) Assuming the machine is at 22 °C when it is switched on, find the number of hours the machine can run continuously for before having to be switched off.

(ii) Suggest a reason why it may be better to switch the machine off before it reaches this temperature?

(2 marks)

6 (a) A patient takes some medication at midday. The amount of drug, D mg, remaining in their bloodstream h hours after midday is modelled by the formula

$$D = 0.06 + 0.21h - ah^2$$ where a is a constant

What amount of drug is already naturally occurring in the patient's bloodstream before taking any medication?

(1 mark)

(b) After six hours the amount of drug in the patient's bloodstream has returned to its natural level. Find the value of a.

(2 marks)

(c) It is particularly dangerous for the patient to take any other medication whilst the amount of this drug in their bloodstream remains at 0.3 mg or higher.
Find the times between which the patient should refrain from taking any other medication.

(2 marks)

7 (a) Last year, a company sold 15 000 copies of a book, at a price of £25 each.
This year, the company wants to increase the price of the book and predicts that for every £2.50 increase in price, annual sales will drop by 750 books.

The formula $N = a + bc$ is used to model the number of books sold annually. Where N is the number of books sold, c is selling price of the book and a and b are constants.

Find the values of a and b and hence, write down the model used for the number of books sold annually.

(2 marks)

(b) Write down an equation for I, where £I is the annual income generated from sales of the book.

(1 mark)

(c) Find the maximum amount of income the company should get from sales of the book this year, the price they should charge for each book and the number of books they should sell.

(3 marks)

8 (a) A slow-motion camera is used to record the motion of a cricket ball projected directly upwards from ground level. The motion of the cricket ball is modelled by the function

$$h(t) = 15t - 4.9t^2 \qquad t > 0$$

where h metres is the height of the cricket ball above ground level after t seconds.
The camera will capture the cricket balls' motion whilst it is between heights of 2 m and 4 m above the ground.

Find the maximum height the cricket ball reaches and how long it takes to reach this point.

(2 marks)

(b) Find the times between which the camera will capture the cricket ball's motion.

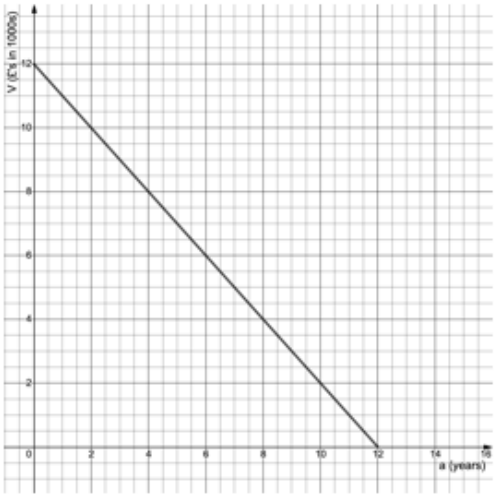
(2 marks)

(c) The slow-motion camera slows real-time down 200 times. So, 1 second of real-time recorded footage would be 200 seconds of slow-motion footage.

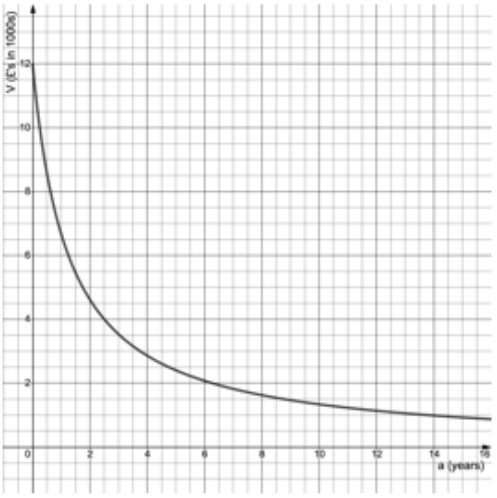
How many seconds of slow-motion cricket ball footage will the camera capture?

(2 marks)

9 (a) The graphs below show two different suggested models for estimating the value of a brand new car costing £12 000. a is the car's age in years and £V is the car's value in thousands.



Model 1



Model 2

Other than when brand new, at what age do the two models predict the same value for the car?

(1 mark)

(b) The value of one particular car was tracked and recorded every two years as shown in the table below.

Age	2	4	6	8	10	12
Value	£10 200	£7 600	£4 300	£2 000	£1 600	£1 200

The car was scrapped after 14 years with the value for parts given as £200.

Based on the data given above, compare the two models in terms of their suitability and comment on which you think is a more suitable model. Justify your choices.

(3 marks)

10 (a) A fountain is designed so that water is projected over a walk way. The path of the water is modelled by the formula

$$y = x(6 - x) \qquad 0 \leq x \leq 6$$

where x is the horizontal distance in meters from the base of the fountain at ground level and y is the height of the water in metres.

Sketch the graph of the model, labelling any intersections with the coordinate axes and the maximum point the fountain reaches.

(2 marks)

(b) The average person is 1.7 m tall and needs a ground width of 1.2 m in order to walk comfortably.

Work out the maximum number of average sized people that can comfortably walk under the fountain side by side without getting wet.

(2 marks)

(c) Using a model of the form $y = x(A - x)$, work out the minimum ground width of the fountain required in order for three average sized people to comfortably walk side by side under the fountain without getting wet.

(5 marks)