QUEENSLAND ACADEMY OF SCIENCE MATHS AND TECHNOLOGY

Mathematics IA

SL Type 2

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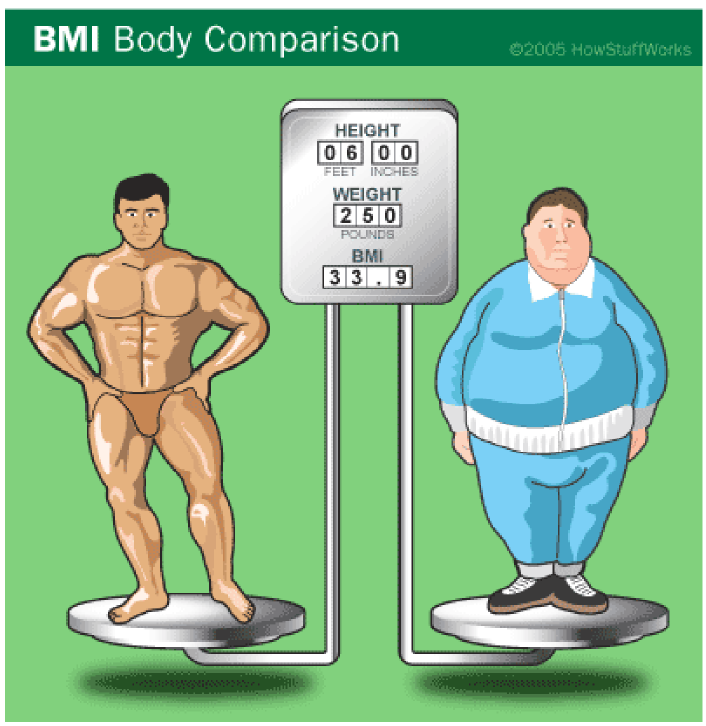
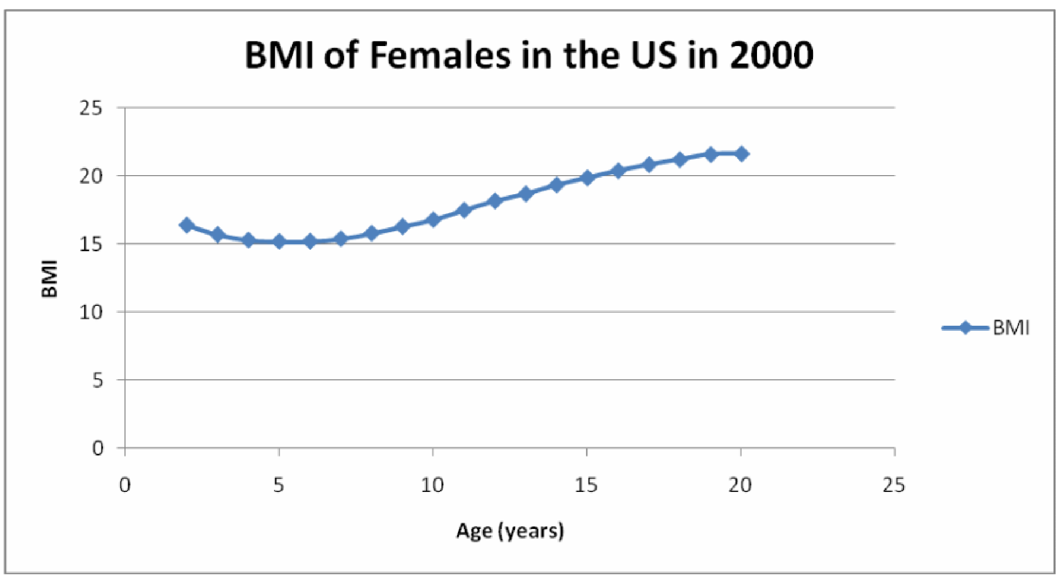


This Internal Assessment will investigate models of female BMI data. BMI is the measure of one's weight to their height. To calculate a per son's BMI their weight is divided by the square of their height. Shown below is data for female BMI values in the US in 2000.

Age (years)	BMI
2	16.40
3	15.70
4	15.30
5	15.20
6	15.21
7	15.40
8	15.80
9	16.30
10	16.80
11	17.50
12	18.18
13	18.70
14	19.36
15	19.88
16	20.40
17	20.85
18	21.22
19	21.60
20	21.65

The data points shown above were graphed, the resulting graph is shown below.



The variables that were used in the graph above were age and BMI. The independent variable, age, was plac ed on the x axis. Age is the independent variable because it is constant. The dependant variable, BMI, was placed on the y axis. BMI is the dependant variable because is varies, dependant on the age.

It is clearly shown in the graph above that the BMI of f emales in the US in 200 can be modelled using the equation y= A sin (Bx -c) + D. This is because the graph is shown to have the same characteristics of a sin graph. In this equation A is the amplitude of the graph.

$$A = \frac{max - \min}{2}$$

Where max = maximum dependent variable value and min = minimum dependent variable value. The maximum value obtained from the data is 21.65 whereas the minimum value is 15.20. These values were then substituted into the equation, this is shown below.

$$A = \frac{21.65 - 15.20}{2}$$

$$\therefore \boldsymbol{A = 3.225}$$

In the sin equation aforementioned B is the measure of how much the graph is stretched horizontally. B is calculated using the equation shown below.

$$B = \frac{2\pi}{period}$$

However, the period of this graph is unknown. To find the period of the graph the equation shown below must be used.

$$Period = (\max + \min) \times 2$$

Where max = the maximum independent variable value and min = the minimum independent variable value. The maximum independent variable value = 20 and the minimum independent variable value = 5. These values were read of the data table, shown above, and then substituted into the equation, shown below.

$$Period = (20 - 5) \times 2$$

$$\therefore Period = 30$$

With the period discovered, B can be calculated by substituting the period value into the equation, this is shown below.

$$B = \frac{2\pi}{30}$$

$$\therefore \boldsymbol{B = \frac{\pi}{15}}$$

To find out the constant, c, in the sin equation the equation, shown below, is used. C determines the horizontal shift that the graph is translated through.

$$Horizontal\ Shift = \frac{-c}{B}$$

However, the Horizontal shift first needs to be determined. The horizontal shift can be calculated using the equation shown below.

$$Horizontal\ Shift = \frac{(min + max)}{2}$$

Where max = the maximum independent v ariable value and min = the minimum independent variable value. The maximum independent variable value = 20 and the minimum independent variable value = 5. These values were read of the data table and then substituted into the equation, shown below.

$$Horizontal\ Shift = \frac{5 + 20}{2}$$

$$\therefore Horizontal\ Shift = 12.5$$

It is now possible to substitute this value into the equation to find c, this is shown below.

$$12.5 = \frac{-c}{(\frac{\pi}{15})}$$

$$\therefore c = -\left(12.5 \times \left(\frac{\pi}{15}\right)\right)$$

$$\boldsymbol{c = \ -2.618}$$

It is now necessary to find the constant D to produce an accurate equation modelling the graph of Female BMI values. D controls the amount that the graph is shifted vertically. It is found using the equation shown below.

$$D = \frac{max + \min}{2}$$

Where max = maximum dependant variable value and min= minimum dependant value. These values were taken from the data table above and substituted into the equation, this is shown below.

$$D = \frac{21.65 + 15.20}{2}$$

$\therefore D = 18.43$

It is now possible to create an accurate equation using the model y = A sin (Bx+c) + D.

$A = 3.225$

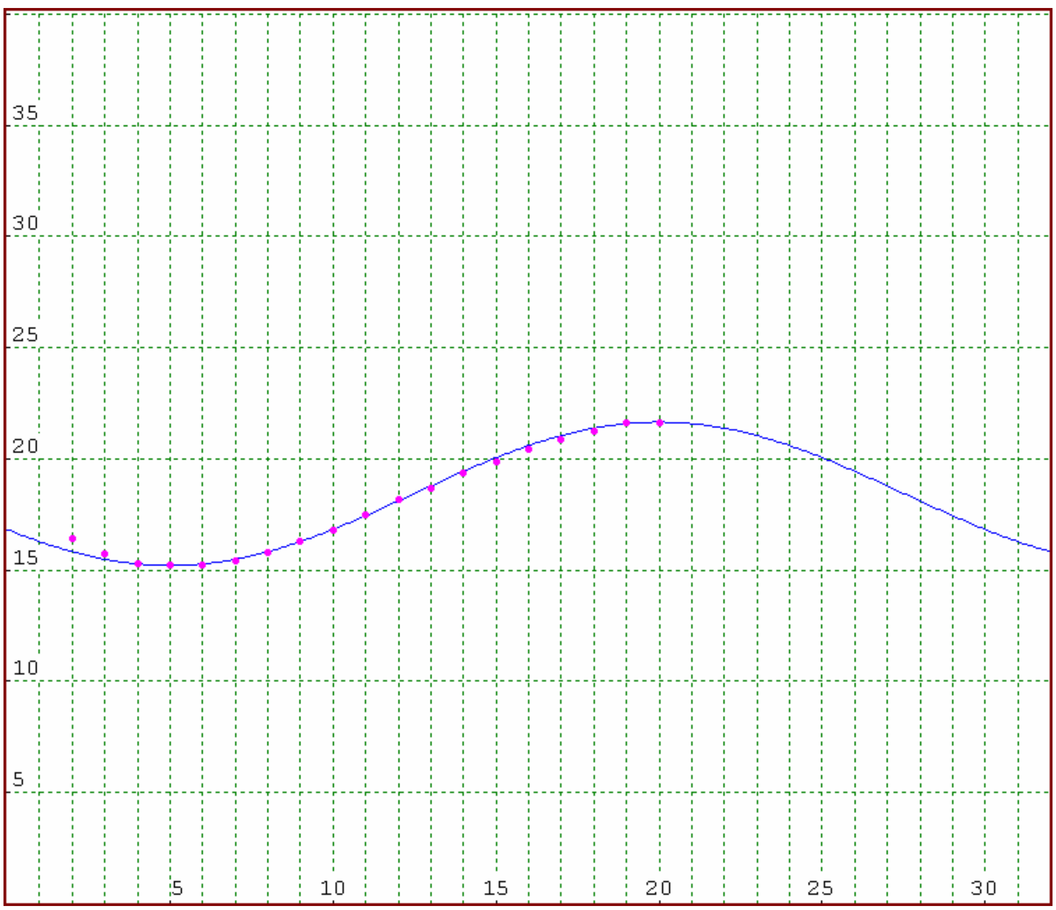
$$B = \frac{\pi}{15}$$

$$c = -2.618$$

$$D = 18.43$$

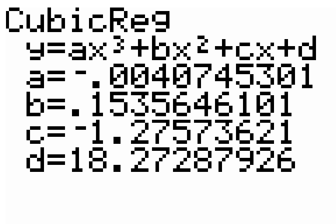
$$\therefore y = 3.225 sin\left(\left(\frac{\pi}{15}\right)x + (-2.618)\right) + 18.43$$

This equation was modelled on the same set of axis as the data points. This is shown below



The x axis is age and the y axis is BMI. The data points are the pink dots and the equation is represented by the blue line. The graph is shown to pass through most of the data points accurately however; it inaccurately depicts the BMI of a 2 year old female and is marginally incorrect on predicting the BMI of a 3 year old female. Therefore, this graph correctly identifies the trend of BMI of females between 4 and 20 in the US in 2000. It is inaccurate to assume that the graph is correct for females above 20 because there is no data to compare it with.

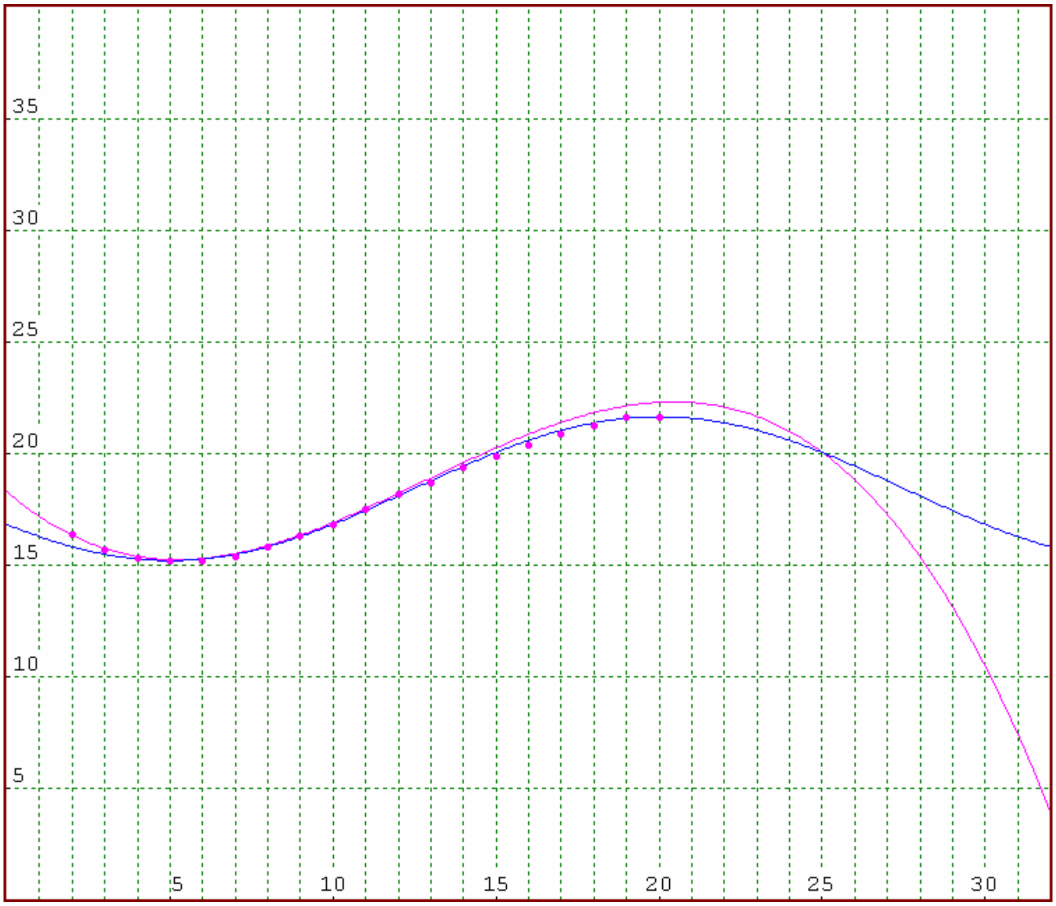
Technology was then used to find another model to depict the BMI of females in the US in 2000. The cubic function was used at it is possible to emulate a sin -like curve with it. A screenshot was taken from a graphics calculator that determined the cubic function that emulates the data points.



The equation modelled by the graphics calculator is shown below.

$$y = -0.004x^3 + 0.154x^2 + (-1.28x) + 18.3$$

To find the advantages and disadvantages of this model against the sin model both equations need to be drawn on the same set of axis with the data points. This is shown below.



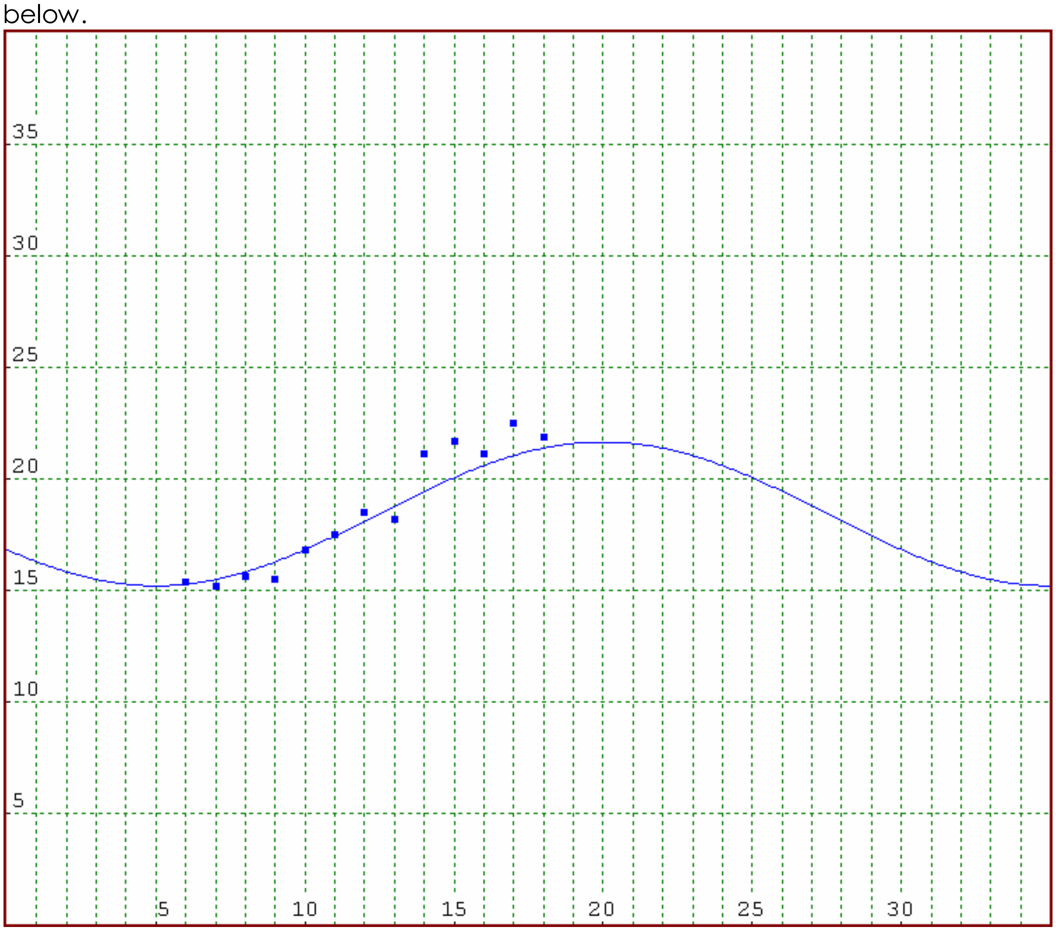
The x axis represents age and the y axis represents BMI values. Th e pink dots are the data points, the blue line is the sin model and the pink line is the cubic model. The cubic model accurately depicts BMI of females from 2 till 16 years of ag e however the graph differentiates noticeably from the data points after 16 years of age. Therefore, the cubic model would only work for females aged 2 to 16 in the US in 2000. Furthermore, the cubic graph declines rapidly from 21 years of age until it reaches zero. However, the sin model declines slowly until rising again because it is a sin graph. Therefore, the sin graph can be said to be more accurate than the cubic model. The cubic model estimates that a 30 year old women living in the US in 2000 would have a BMI of 10.5 . This value is severely below the ideal weight line, it indicates that on average 30 year old women in the US in 2000 were all anorexic. Therefore, the cubic function does not accurately predict values. However the sin function interpre ts that 30 year old women in the US in 2000 would have a BMI of 17. This value is moderately under 18.5, the minimum value for a women's BMI to be considered "ideal". This shows that the sin model is reasonably accurate.

To further prove my sin model anoth er set of values need to be tested. The data below is from girls aged 6 to 18 in Bahrain.

Age(years)	**BMI**

6	15.4
7	15.2
8	15.6
9	15.5
10	16.8
11	17.5
12	18.5
13	18.2
14	21.1
15	21.7
16	21.1
17	22.5
18	21.9

The data was then graphed with the sin model aforementioned. The result is shown below.



The x axis represents age; the y axis represents BMI values. The blue squares are the data points for Bahraini girls and the blue line represents the sin model that was discovered.

The graph above shows that the sin model is marginally incorrect in interpreting BMI values for Bahraini girls. This can be due to differences in height, nutrition and lifestyle from Bahraini girls to American girls. Also the data that was provided was not comprehensive; there were less data points than the set of American values. This can reduce the accuracy of the data points .

To correct the sin model so that it fits the data for Bahraini girls the original model would need to be changed slightly. Firstly, the B value must be altered. This is because B changes how much the graph is stretched horizontally and it is apparent in the graph above that the graph needs to be less "stretched" to coincide with the data values for Bahraini girls. The amplitude, A, would not need to c hanged because it can be seen from the graph that the amplitude is right. The constant that controls how much the graph is shifted left of right, c, would also need to be changed because it can be seen from the graph that the sin model would need to be shifted marginally to the right. D, the measure the vertical translation of the graph, would not need to be changed because the function already models that constant correctly, as can be seen from the graph.. Overall only minor changes would need to be made so that the sin model for American women aged 2 to 20 would fit data point for Bahraini women aged 6 to 18.

Limitations to the sin model include the wave like curve of the graph that the model creates. This is unrealistic as after the age 25 women's BMI s hould not fluctuate like the sin model depicts. This is because after the age of 25 women do not grow anymore, this would provide a straight line graph after the age of 25; this is not what the sin model predicts.

Bibliography

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