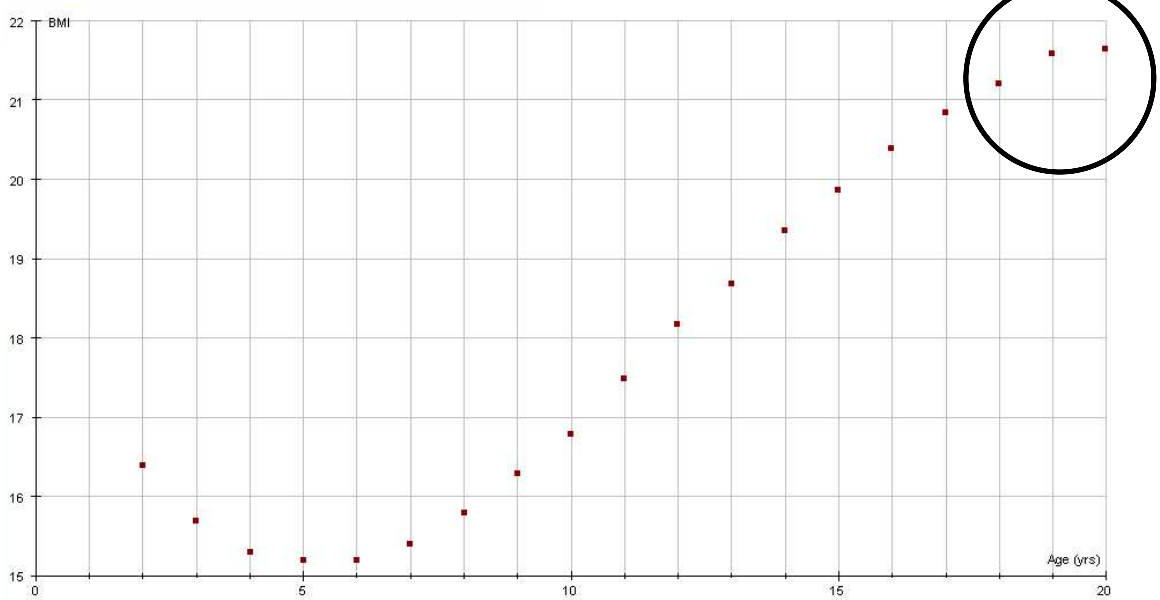
Body Mass Index Maths Coursework
March 2008 By: 12M(2)

This maths coursework is based on Body Mass Index. This is a measure of ones body fat; it is calculated by taking one's weight (kg) and dividing it by the square of one's height (m). For this cour sework, I have to plot a graph for the BMI of different females of different ages in the US in year 2000 and analyse whether it is an accurate source of data and how it can help me to find other BMI's around the world.

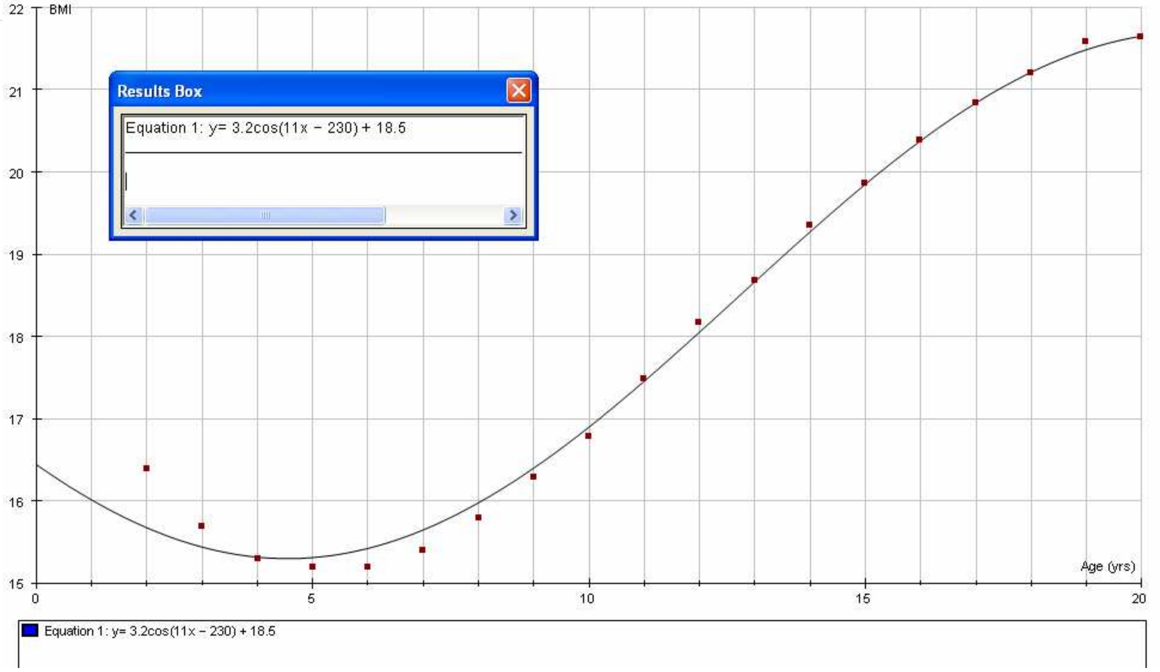
Below is my graph showing the BMI of different females of different ages in the US in the year 2000:



As shown on the graph, the 'x' values are the age of the females and the 'y' values are their body mass index. The age is measured in Years.

When modelling this data, the initial impr ession is to think that is was an $f(x)= x^2$ graph. However once you notice that it is not a mere parabola but a wave due to the curve that levels off (shown on graph) we can assume it is a periodic function such as a cosine or sine graph. Even though you ca n use a cosine or a sine graph, I decided to use a cosine graph, as I am more familiar with this type of graph.

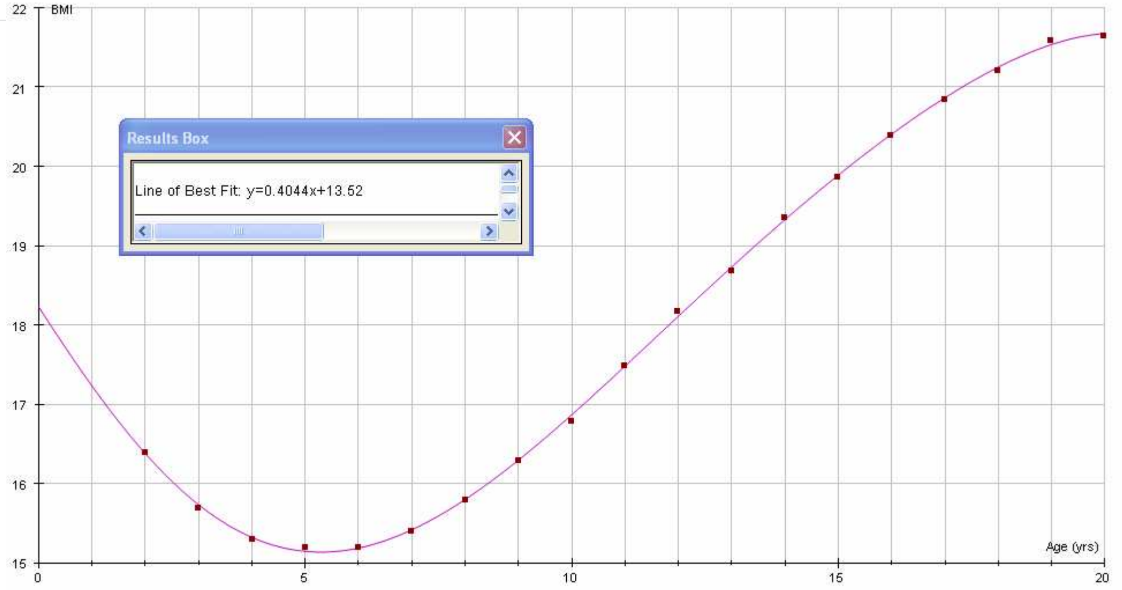
After inputting the cosine function into autograph software, you would realise that transforming the function would be appropriate so that it can model the graph more accurately. In order for you to do this, you have to use the general formula of $f(x)= a\cos(bx + c) + d$. This is because it enables you to transform the function. The function I found was: $f(x)= 3.2\cos(11x -230) + 18.5$. The model is shown below:



When transforming the function, you have to understand the general formula stated above. In order to stretch the graph so that the wave would have the same amplitude; you have to use the function af(x) as it gives a vertical stretch. I put in 3.2 as it seemed appropriate. Then, to make my function wider and create a horizontal stretch by a factor of 1/b, I put 11 in front of the x. Once this was done, I had to translate my whole wave so that it was in the same position as the original parabola; in order to do this, I decided to put - 230 in addition to my 11x. This is because the function f(x+c) causes the function to move left or right (c>0 moves it to the left and c<0 moves it to the right). The function: f(x) + d moves the wave up and down. Therefore, the last thing I had to do was add 18.5 so that I could move the graph 18.5 spaces vertically up.

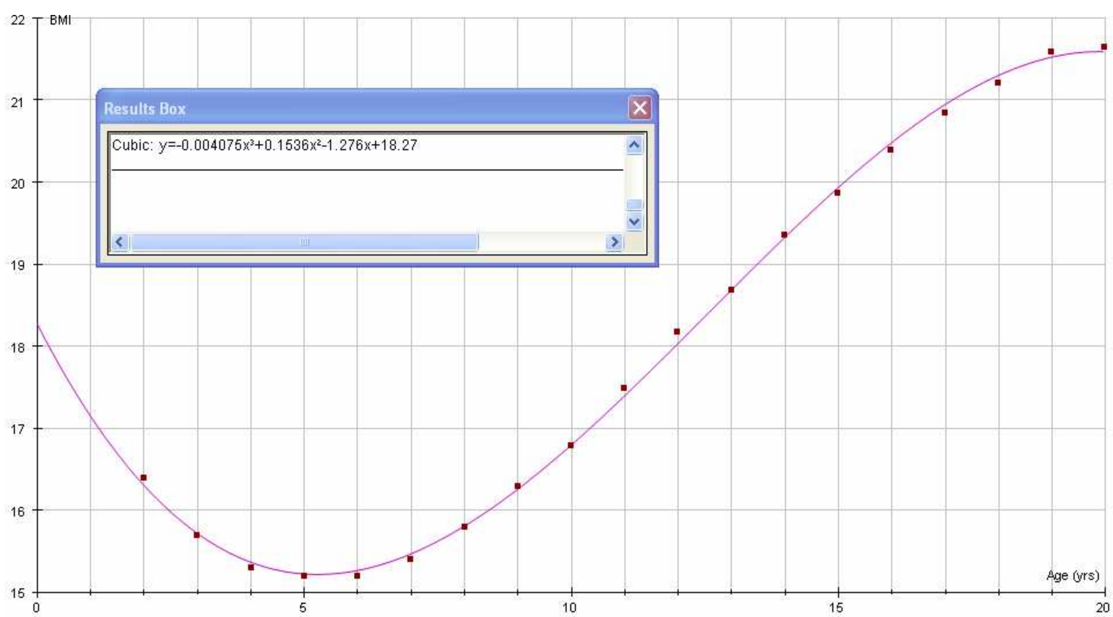
Looking at the above model against my plotted points, you can see that in some places there are inaccuracies. This model was the closest model I could find that fitted my graph and more or less fits my original points. From points 13-20, my model accurately fits my graph. However, from points 2-7 my graph is inaccurate and unreliable as the model is far off the points. Overall, I think that my graph is accurate and can be used when finding general data from people of ages 8-20.

In order to make it more accurate, it would be smart to find the line of best fit for the model I had found. Hence, using autograph software, I found the line of best fit:

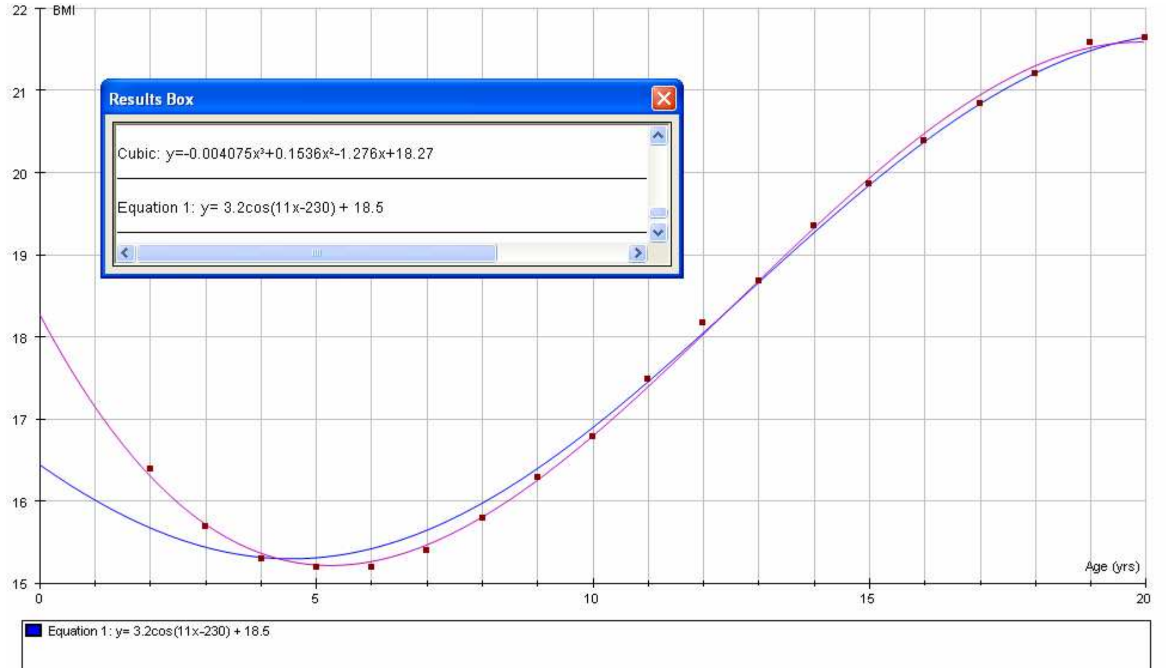


The equation for this line of best fit is: y= 0.4044x + 13.52. This line of best fit is clearly much more accurate than the function I made earlier. As you can see, most of the points accurately touch the points and if they are not, they are very near to the points. This is much more refined than my last model.

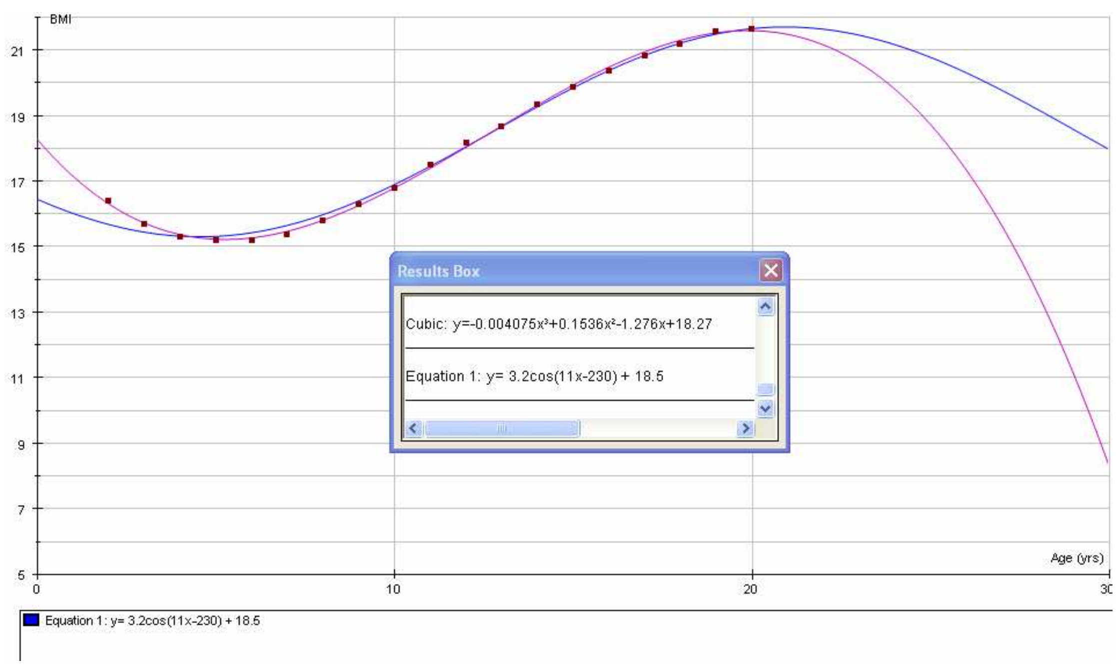
Another function that is possible when modelling this data is a cubic graph, with a general formula of: $y= ax^3 + bx^2 + cx + d$. The function I got was: $y=-0.004075x^3+0.1536x^2-1.276x+18.27$. You can find this function by choosing a line of best fit with a polynomial number of 3. The graph is shown below:



To compare a cosine graph and cubic graph it would be smart to put both these graphs on one axis. The graph is shown below:



There are various differences in the two models. This is expected, as they are two different functions. From ages 0 -4 the cosine model (blue line) is very inaccurate and the cubic function is very accurate as it almost t ouches the points. They are both very accurate when a person is 13 years old as they both touch the point at (13, 18.7) and each other. Overall, it seems as though the cubic graph is much more accurate as it seem to touch many more of the points and also s moothly touches the trough of the curve.



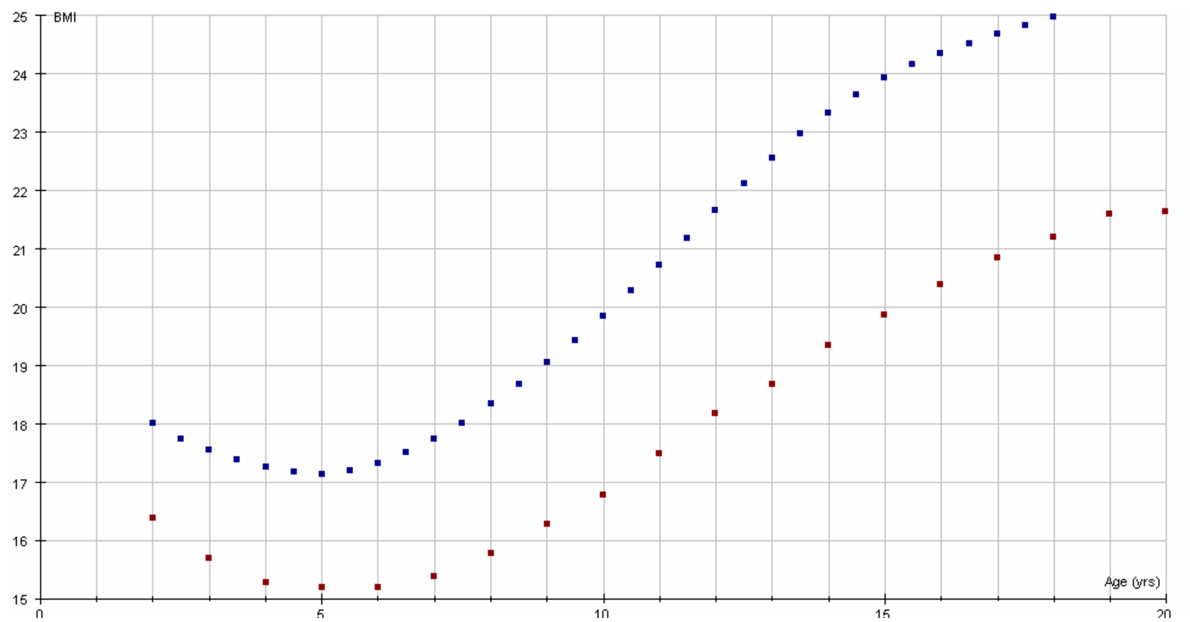
As shown above, extending the x axis to 30 can show a possible trend. If you look at both the cubic and cosine graph you can see that they both decrease. Hence, we can say that a person of 30 years old will h ave a lower BMI than a person of 20. However, the rate at which the BMI falls is much slower in a cosine graph than in a cubic graph as it is much steeper and has different gradients. If you substitute the x value of 30 in the equations we can find and prediction for each of the graphs. According to the cosine graph, substituting 30 into the equation ($f(x)= 3.2\cos(11(30) -230) + 18.5$) equals 17.9 (to 3 s.f.). Thus according to the cosine graph, a woman aged 30 years old will have a BMI of 17.9. However, if we substitute 30 in the cubic equation we will find a completely different answer: ($y=-0.004075(30)^3+0.1536(30)^2-1.276(30)+18.27$) as this equals 8.21 (to 3 s.f.). Hence, according to the cubic graph a woman aged 30 would have a BMI of 8.21. There are two d ifferent answers because both the graphs have different trends. The only way to find out which graph best suits is do more primary research and continue the points until we see more of a trend. This is quite unreasonable because many people say that as a women grows older she gets much more over weight. Furthermore, getting two results for the BMI depending on what graph it is, is very inaccurate and impractical.

When comparing the BMI of other females in other countries, this graph also seems to be very inaccurate. These are the results showing the BMI of Australian females aged between 2 -18 in the year 2002:

Age (yrs)	BMI
2	18.02
2.5	17.76
3	17.56
3.5	17.40
4	17.28
4.5	17.19
5	17.15
5.5	17.20
6	17.34
6.5	17.53
7	17.75
7.5	18.03
8	18.35
8.5	18.69
9	19.07
9.5	19.45
10	19.86

10.5	20.29
11	20.74
11.5	21.20
12	21.68
12.5	22.14
13	22.58
13.5	22.98
14	23.34
14.5	23.66
15	23.94
15.5	24.17
16	24.37
16.5	24.54
17	24.70
17.5	24.85
18	25.00

The graph obtained from this informat ion is shown below:



As you can see, for both countries you can use a cubic and a cosine graph as they both have fairly the same shape. However, you can see that Australian people have a much higher BMI than American people. This can be due to various reasons such as: height, body fat, muscle etc;. These to graphs therefore show that people in Australia are much more overweight than people in America. In order for me to change my model so that it fits with the Australian BMI data. For my cosine graph, I will have to increase the value of f(x) + d. This is because this is what translates it upwards. However my f(x + b) will be unchanged because I am not trying to translate horizontally as the ages are the same. As for af(x), I will have to change it slight ly as the Australian results have a larger vertical stretch. Lastly, my f(ax) will have to be changed slightly because the Austalian results are a little narrower than the American results. However, most of the values will only have to be changed slightly as the general trends of the graphs are the same.

There are various limitations to my model. Firstly, there are much more results for my Australian data. This means that it is much more accurate. However, my American data has a wider age range, this makes it easier to see a trend than with my Australian data. Furthermore, the dates are different. The BMI was recorded in America in 2000, while the BMI in Australia was taken in 2002. Hence, Australia has much more recent results and are much more up to date. This means that this is just a vague comparison and is incorrect as it is not a fair test because many of the variables are changed.

In conclusion, the analysis of body mass index is very ambiguous and is a complicated procedure.

Bibliography:

1. **Autograph Software**
2. **http://www.health.gov.au/internet/wcms/publishing.nsf/Content/health-pubhlth-strateg-hlthwt-obesity.htm**