



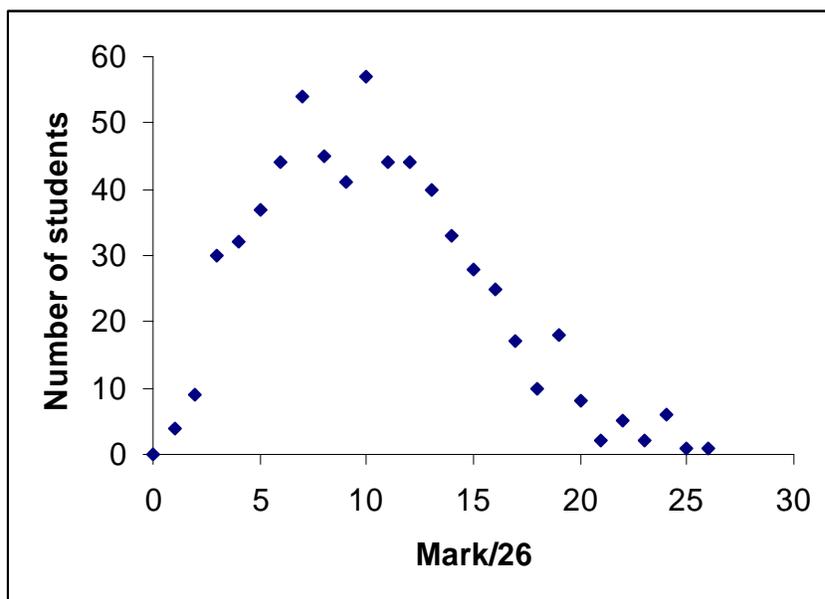
# Michael Smith National Science Challenge 2008

Monday, April 7th, 2008

## Marking Scheme and Analysis

### Introduction

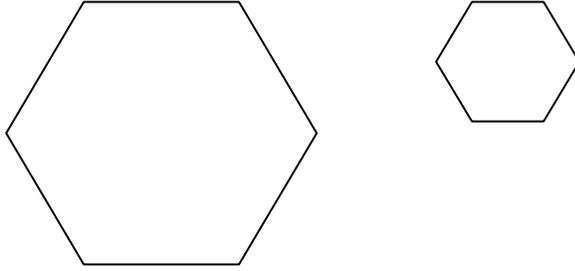
A total of 640 students took part from 8 provinces; 321 male, 306 female and 13 who did not give this information. All 6 questions were marked out of 5. The overall distribution of marks is given below. The mean was 10.3/30 and the highest score was 26/30.



Participation by province:

BC	312
AB	68
SK	28
ON	155
QC	40
NS	2
NB	7
NL	28

1. This is a map of two hexagons marked out in the grass on a school playing field.



(a) If it takes you a minute to walk around the edge of the smaller one, how long does it take to walk around the edge of the larger one?

One side of the larger hexagon is slightly larger than twice that of a side of the smaller. Hence the perimeter of the larger is slightly more than twice that of the smaller. We accept any answer around 2-2.2 minutes (2 marks)

(b) If there are a million blades of grass inside the smaller hexagon, estimate how many there are inside the larger hexagon.

For objects of the same shape the ratio of areas is the square of the ratio of any given pair of lengths (side, perimeter etc.). Hence if there are a million blades in the smaller hexagon there are about  $2^2 = 4$  times as many in the larger. We accept any answer that is the square of the ratio used in part (a): i.e. 4 – 5 million (3 marks).

Part (a) was generally well done. A typical error in part (b) was not to realize that the area of any shape is proportional to the square any given length, i.e. one side or the whole perimeter.

Mean score: 3.5/5.

2. (a) A human has genotype  $A_1A_1B_1B_2$ . What gametes will a single meiosis produce and in what proportions?

$A_1B_1$  (50%),  $A_1B_2$  (50%) (1 mark for right gametes; 1 for right proportions)

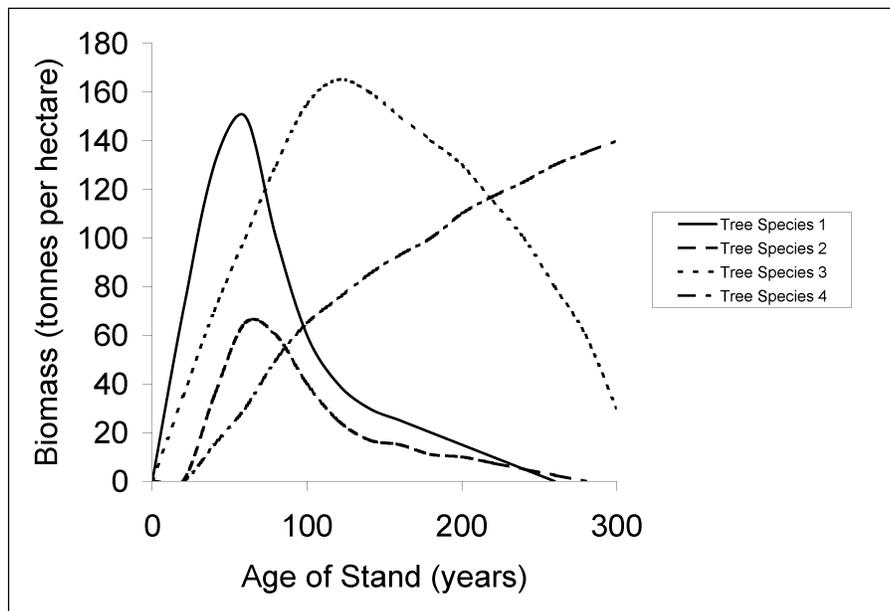
(b) A human has genotype  $A_1A_2B_1B_2$ . What gametes will many meioses produce and in what proportions?

$A_1B_1$ ,  $A_1B_2$ ,  $A_2B_1$ ,  $A_2B_2$  (25% each) (2 marks for right gametes; 1 for right proportions)

This was a question that students seemed either to know how to answer or not.

Mean score: 1.3/5.

3. The graph shows changes in a community of plants following a disturbance at time zero. The quantity of each species is measured in tonnes per hectare. Just from looking at the graph, suggest a plausible general explanation as to why tree species 1 and 2 disappear. Please answer in two or three sentences.



Somehow the slow rise of species 3 and 4 caused the initially successful species 1 and 2 to die back. Eventually 3 dies back also. (2 marks for recognition alone).

Possible cause: species 3 and 4 are canopy trees (4 higher than 3) and 1 and 2 are not shade tolerant.

Full 5 marks for any reasonable *single* explanation why of the success of 3 and 4 should cause the demise of 1 and 2.

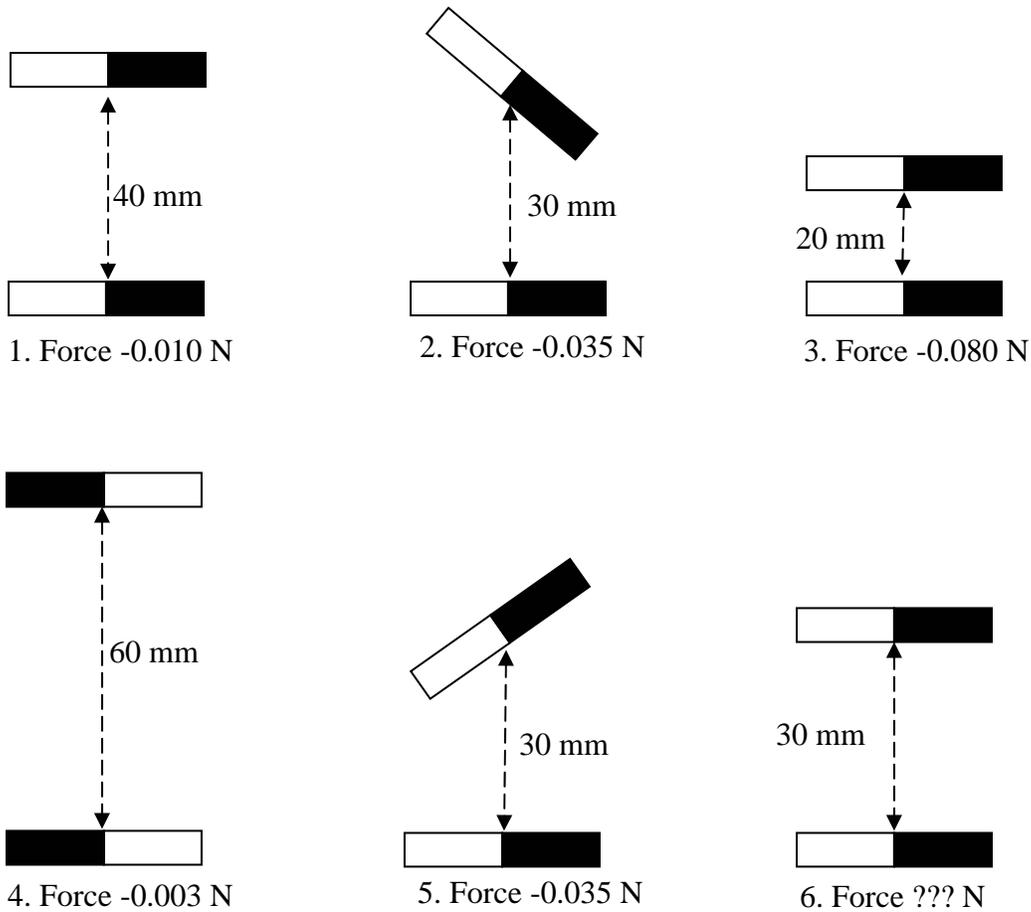
1 mark for any "just so" explanation which kills off 1 and 2 with no relationship to the rise of 3 and 4. Note that if 1 and 2 were merely short lived, the area would reseed (the vertical axis is biomass per unit area), so no marks for that idea.

A total of 22 students suggested a connection between the death of 1 and 2 and the rise of 3 and 4.

Mean score: 1.4/5.

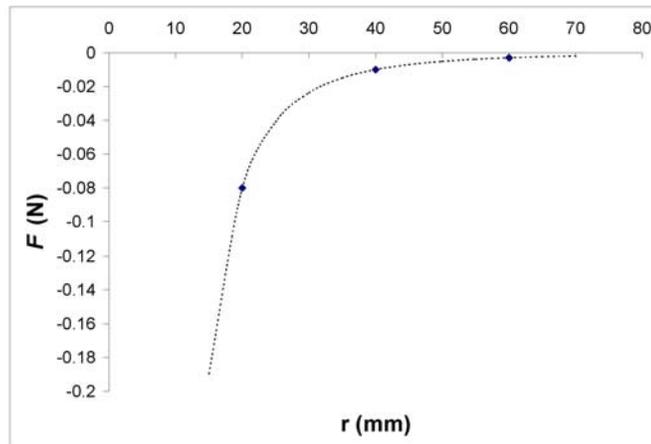
4. You are investigating the nature of the force between two identical magnets by making measurements with the magnets set at various distances and angles with respect to each other. Your measurements are shown below for five cases. The black end of the magnet is north and the white end south. The force measured is that on the lower magnet and the sign convention is that up is positive, and down negative. The distances are measured between the centres of the magnets.

Use these observations to predict the force on the lower magnet in case number 6. Show your working.



## Solution to 4.

This is a carefully worded problem to test if students can pick relevant information out of a larger dataset. A quick look at the pictures (and/or personal experience) reveals that the force between two magnets is highly nonlinear as a function of distance between them. Hence the two situations with tilted magnets (#2 and #5) will not be the same as the force in #6, even though the mean distances are the same. The force will be dominated by the closer halves of the magnet and will be larger (in magnitude) than the force in #6. The only way to estimate the force in #6 is to consider cases #1, #3 and #4. The best way is to graph them.



Full 5 marks for any kind of graphical or nonlinear interpolation: -0.024 N

4 marks for a linear interpolation of 20mm and 40mm: -0.045 N

3 marks for rejecting cases #2 and #5.

0 marks if no working shown.

Any student who notices the force is proportional to  $1/r^3$  will be congratulated!

A total of 67 students selected the right situations to consider and interpolated reasonably; 9 of them figured out (or just possibly knew) the inverse cubic relationship.

Mean score: 1.7/5.

5. The Alberta Energy website states “Every two weeks Alberta produces enough coal to fill the Sky Dome in Toronto”. The Skydome is a baseball/football stadium.

- (a) Estimate as best you can the volume of the Skydome, in  $\text{m}^3$ .
- (b) Assuming all this coal is burned, and that coal is mostly carbon, estimate the mass (in tonnes) of carbon dioxide produced by the Alberta coal industry *in a year*.

You can assume a  $\text{m}^3$  of coal has a mass of about 1 tonne (1000kg).

Skydome		
Radius	100 m	
Height	50 m	
Volume	$1.57\text{E}+06 \text{ m}^3$	
Density coal	1000 $\text{kg}/\text{m}^3$	Varies from 800-1500, i.e about same as water
Mass coal/2weeks	$1.57\text{E}+09 \text{ kg}$	
Mass coal/year	$4.08\text{E}+10 \text{ kg}$	
Mass coal/year	41 Mtonnes	
Mass carbon/year	41 Mtonnes	Assuming coal is all carbon. (A high estimate)
Mass $\text{CO}_2$ /year	150 Mtonnes	

The same website says Alberta produces 25Mtonnes of coal annually, so this number is a little high.

2 marks for any reasonable estimate of the Skydome volume (within a factor 10 either way).

1 mark for correct conversion of two weeks to one year.

2 marks for recognizing that 12 tonnes of carbon burn to 44 tonnes of  $\text{CO}_2$  (i.e. in the ratio of the molecular weights).

A total of 198 students made a reasonable shot at the volume of the Skydome; 48 went on to estimate the  $\text{CO}_2$  mass reasonably. Common errors were forgetting or incorrectly converting from 2 weeks to 1 year, and not knowing how to get from carbon mass to  $\text{CO}_2$  mass.

Mean score: 1.4/5.

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6. When the magnetic fields trapped in the rocks of the ocean floor were measured, the following pattern was seen.



The dotted line is the mountainous mid-ocean ridge, running north-south. The white areas and black areas have magnetic field in the opposite direction. One is “normal”, i.e. the magnetic field is the same direction as it is at the ocean surface. The other is reversed, i.e. the magnetic field is opposite what it is at the ocean surface.

(a) What is going on here? (Answer in 20 words or less)

3 marks for recognizing that the ocean floor is spreading away from the central ridge (1) and that the stripes indicate the earth's field direction at the time the molten rock reached the ocean floor (1) and solidified (1).

(b) Why is the pattern symmetrical about the mid-ocean ridge?

Equal rates of ocean floor spreading on either side. (1)

(c) Do the black stripes have normal or reversed field?

Reversed: the current field direction is indicated by the colour at the centre (white). (1)

This was the most difficult question; the concept of freezing in the current magnetic field when rock solidifies is fairly sophisticated. Only 14 students gained full marks in (a), although 115 recognized the reason for the symmetry in (b). Out of 640 students, 359 got (c) right, which is only a slightly better result than random guessing.  
Mean score: 1.0/5.

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