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APPENDICES

APPENDIX 1A: SYLLABUS ON APPLICATION OF THE DEFINITE INTEGRAL

The section to be covered on volumes on application of the definite integral is indicated below as stipulated in the syllabus, so that the researcher can ensure that the proper standards are maintained in terms of how students are taught and assessed in class. Other sections can be referred to in the Syllabus for Mathematics N6 (1996).

√ MODULE 5: APPLICATIONS OF THE DEFINITE INTEGRAL

All the applications in this module must be done as follows:

- Draw a neat sketch of the relevant curves and clearly indicate the relevant points of intersection after suitable calculations.
- Indicate the representative strip and the relevant limits, as well as the distance to the reference axis when moments are to be determined.
- Give the equation for the volume, centroid, moment etc. of the representative strip.

- Apply the operation for summation (Determine the correct definite integral.)

NB Only curves prescribed in the N1 to N6 Syllabi will be examined.

√ Volumes

On completion of this topic, the student should be able to calculate the volume developed when an area enclosed between a given curve and an axis, or between two given curves is rotated about a reference axis, with the specific application of the representative strip being parallel to the axis about which the area is rotated (the tin effect). (Syllabus for N6, 1996:10)

APPENDIX 1B: PRELIMINARY STUDY 2005

RESEARCH ON SOLIDS OF REVOLUTION: MATHEMATICS N6

RESEARCHER: BLK MOFOLO 04 JULY 2005: TEST 1

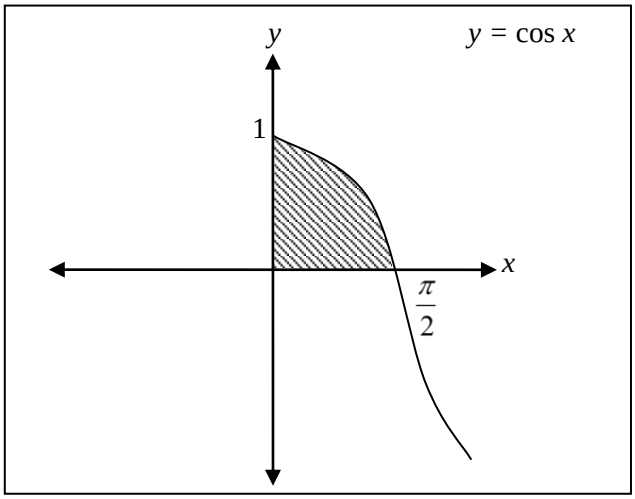
ANSWER ALL QUESTIONS ON THE WORKSHEET

Instructions: **In all the questions show the solid of revolution, the method used and the strip.**

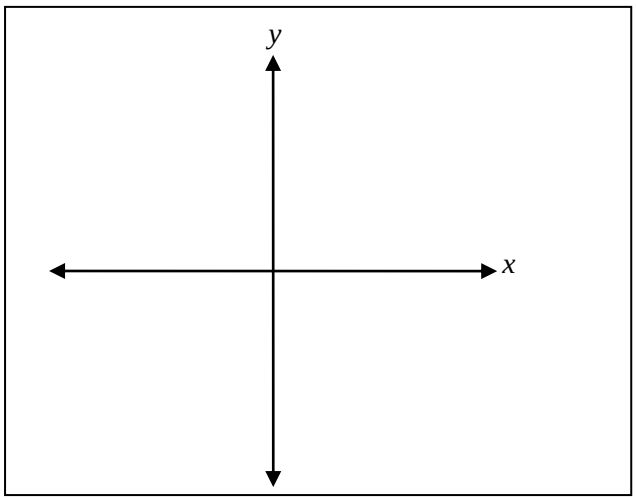
Question 1

Find the volume generated when the area bounded by the graphs is rotated about the X-axes.

(a) $y = \cos x$



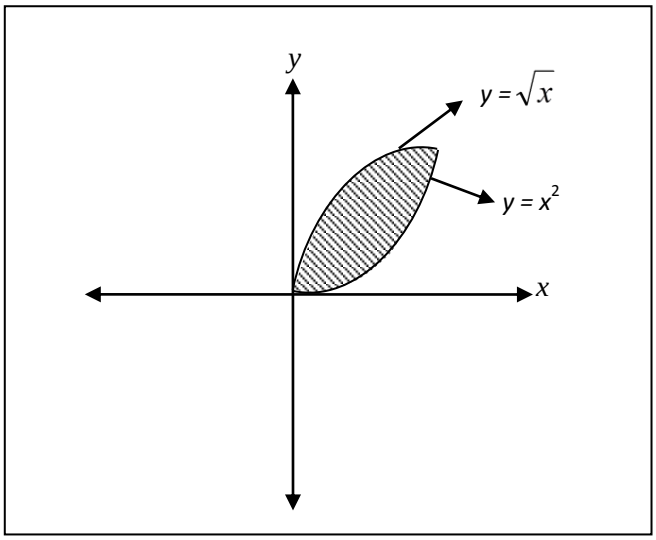
(b) $y = x^2$ and $x = 3$. (Draw the graph and shade the area used)



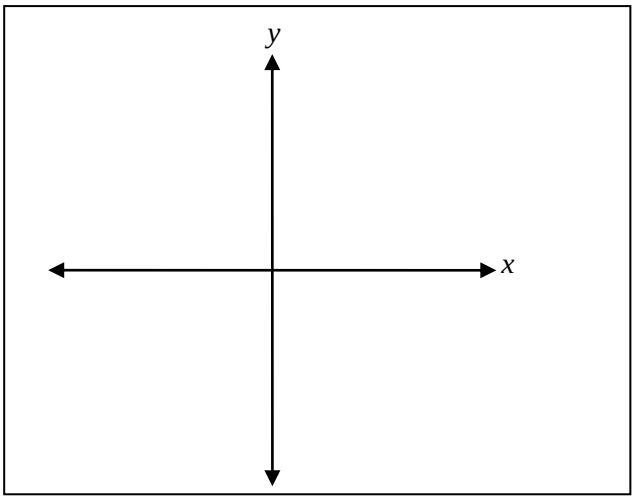
Question 2

Find the volume generated when the area bounded by the graphs is rotated about the Y-axes.

(a) $y=\sqrt{x}$ and $y=x^2$



(b) The first quadrant area of $x^2+y^2=9$. (Draw the graph and shade the area used)
$y=x^2$ and $x=3$. The first quadrant area of $x^2+y^2=9$.



RESEARCH ON SOLIDS OF REVOLUTION: MATHEMATICS N6

RESEARCHER: BLK MOFOLO 07 JULY 2005: TEST 2

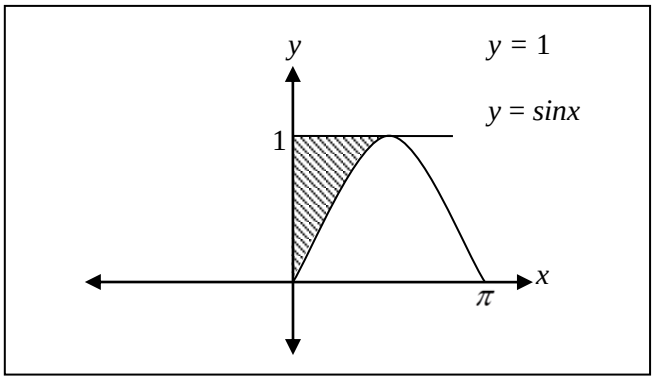
ANSWER ALL QUESTIONS ON THE WORKSHEET

Instructions: **In all the questions show the solid of revolution, the method used and the strip.**

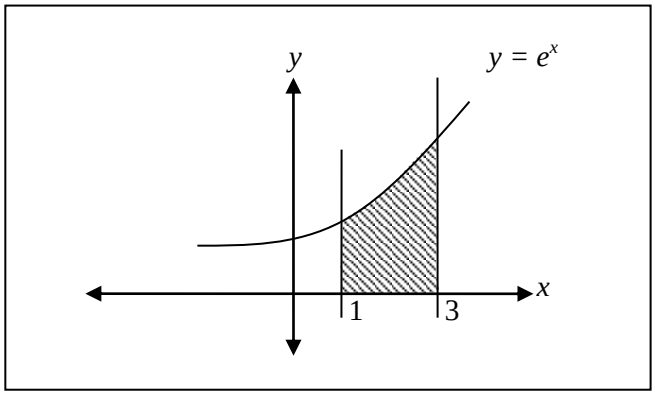
Question 1

Find the volume generated when the area bounded by the graphs is rotated about the X-axes.

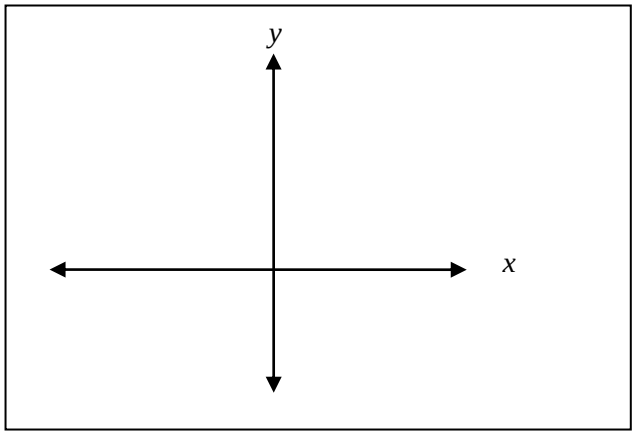
(a)



(b) $x = 1;\quad x = 3$ and $y = e^{x}$



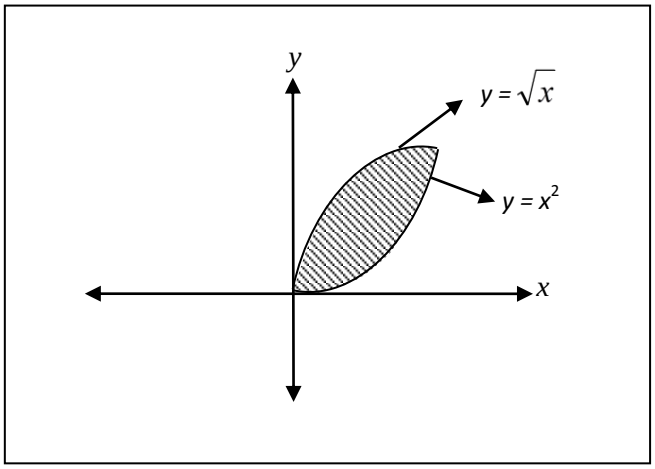
(c) $y^{2} = x^{2} + 1;\quad y = 2$ and $y = 4$. (Draw the graph and shade the area used)



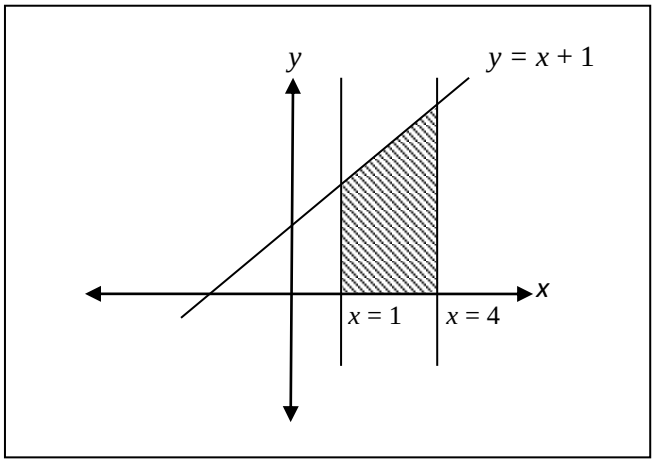
Question 2

Find the volume generated when the area bounded by the graphs is rotated about the Y-axes.

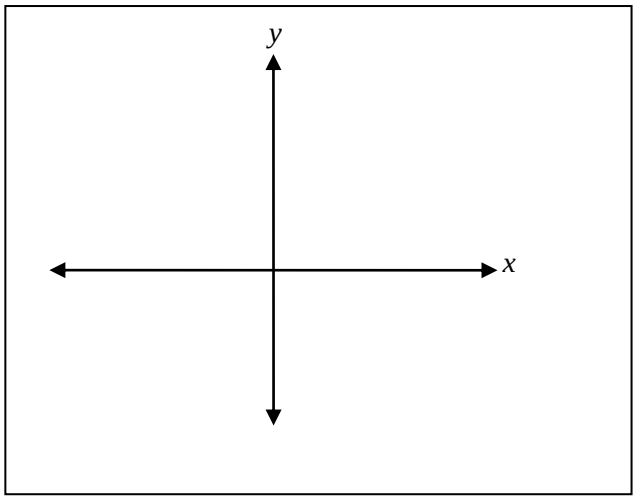
(a)



(b)



(c) $y^2 = 4x$ and $y = 2x - 4$. (Draw the graph and shade the area used)



APPENDIX 2A: PILOT (2006) BEFORE RESHUFFLED **Researcher: Mofolo BLK**

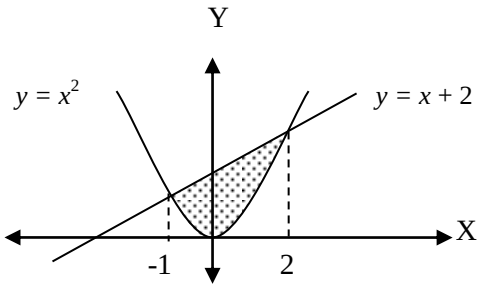
1. A LG ⟶ VS (2D)

1A. Represent $x^2 + y^2 \le 9$ by a picture.

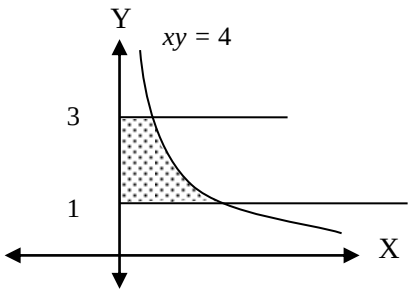
1B. Represent $\int_0^1 (x - x^2)\,dx$; by a picture

2. VIS ⟶ ALG (2D)

2A. Give the formula for the area of the shaded region.



2B. Give a formula for the area of the shaded region.



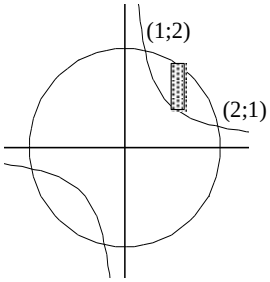
3. A LG ⟶ VS (3D)

3A: Draw the 3D solid of which the volume is given by $V = \pi\int_0^1 (1-x^2)^2\ dx$

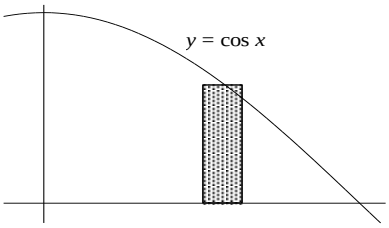
3B: Draw the 3D solid of which the volume is given by $V = 2\pi\int_0^1 x(1-x^2)\ dx$

4. VIS ⟶ ALG (2D)

4A: Below the 1st quadrant area bounded by graphs of $x^2 + y^2 = 5$ and $xy = 2$ is selected using the given strip. Give the formula for the volume generated if this area is rotated **about the *x*-axis.** Do not calculate the volume.



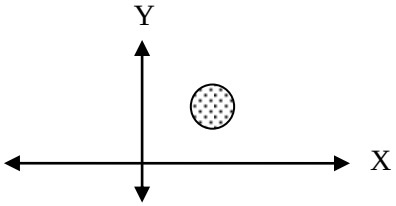
4B: Below the region bounded by the graph of $y = \cos x$, the *x*-axis and the *y*-axis is selected by the given strip. Give the formula for the volume generated when this area is rotated **about the *y*-axis.**. Do not calculate the volume.



5. 2D ⟶ 3D

5A: Draw the solid that will be formed if a line with a positive gradient passing through the origin is rotated about the *x*-**axis**, where $x \in [0,3]$.

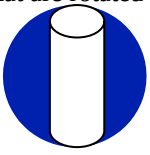
5B: What solid do you get if you rotate the circle below about the ***y*-axis**?



6. 3D ⟶ 2D

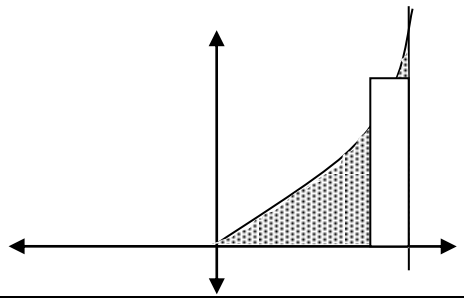
6 A: Discuss how a hemisphere is generated as a solid of revolution.

6 B: A hole with radius 2 cm is drilled through the centre of the sphere of radius 5 as in the picture. Describe the curves that are rotated to generate this solid.



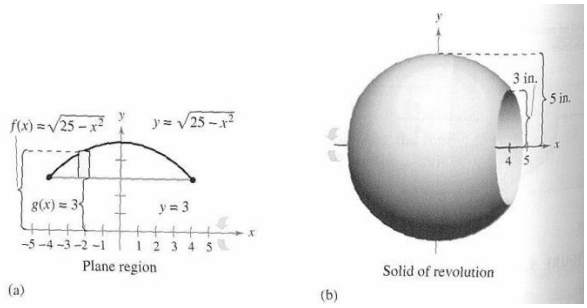
7. CONTINUOUS ⟶ DISCRETE (VIS) 2D

7 A: Sketch three additional rectangles (similar to the given rectangle) so that the total area of the rectangles approximates the shaded area.

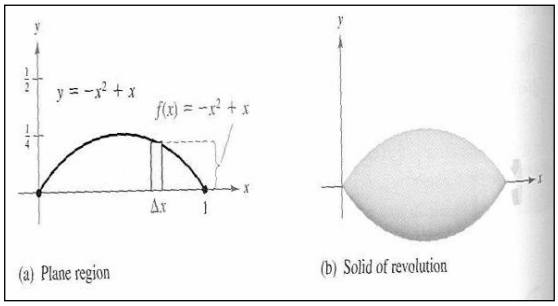


8. CONTINUOUS ⟶ DISCRETE (VISL) (3D)

8A: When the graph below is rotated, the solid on the right is generated. Show how you would cut the solid in appropriate shapes (discs, shells or washers) to approximate the volume of the solid.



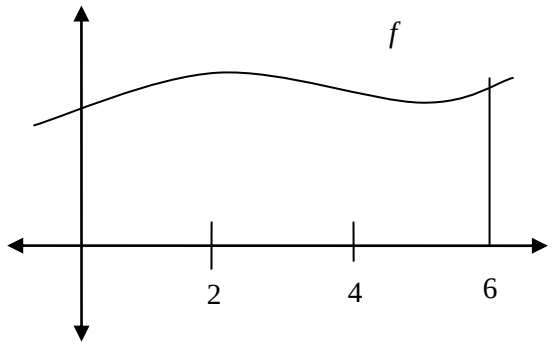
8 B: When the graph below is rotated, the solid on the right is generated. Discuss how you would cut it to generate either (discs, shells or washers).



9. {DISCRT ⟶ CONTNS and CONTS ⟶ DISCRT } (ALG)

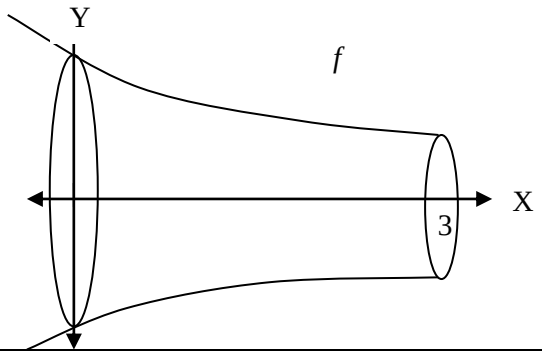
9 A: Show what the following represent with a sketch.

$2f(0) + 2f(2) + 2f(4)$



9 B: If the volume of the given solid of revolution is approximated by discs, sketch the discs that would give the volume.

$\pi(f(0))^2 + \pi(f(1))^2 + \pi(f(2))^2$



10. ALGEBRAIC SKILLS

10 A : Calculate $\int_0^1 \pi(1-x^2)^2\,dx$

10 B: Calculate $\int_0^1 2\pi x(1-\sin x)\,dx$

11. COGNITIVE SKILLS

11 A: Given the graphs of $y = \sin x$ and $y = 1$

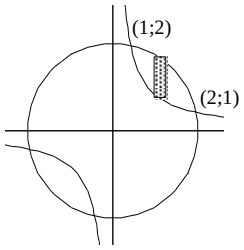
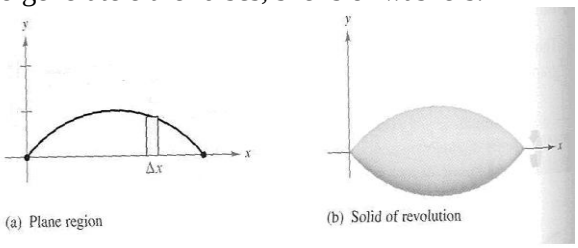
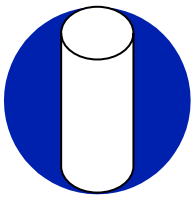
(i) Draw the graphs and shade the area bounded by the graphs and $x = 0$

(ii) Show the rotated area about the ***y*-axis** and the strip Used

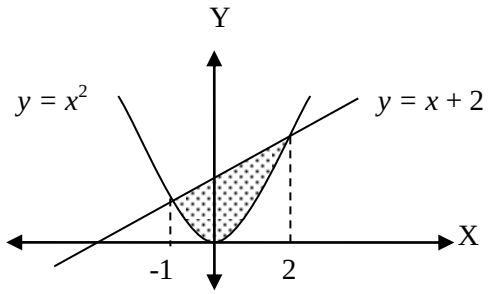
(iii) Write down a formula to find the volume when the region between $y = \sin x$ and $y = 1$ is rotated about the ***y*-axis**.

11 B: Use integration methods to derive the formula of a volume of a cone of radius *r* and height *h*.

APPENDIX 2B: PILOT ADMINISTERED 2006 **Researcher: Mofolo BLK**

1: Below the 1st quadrant area bounded by graphs of $x^2 + y^2 = 5$ and $xy = 2$ is selected using the given strip. Give the formula for the volume generated if this area is rotated **about the *x*-axis.** Do not calculate the volume. 	
2: Calculate $\int_0^1 \pi (1-x^2)^2 \, dx$	
3: When the graph below is rotated, the solid on the right is generated. Discuss how you would cut it to generate either discs, shells or washers. 	
4: Draw the solid that will be formed if a line with a positive gradient passing through the origin is rotated about the ***x*-axis**, where $x \in [0,3]$.	
5: Represent $x^2 + y^2 \leq 9$ by a picture.	
6: A hole with radius 2cm is drilled through the centre of the sphere of radius 5cm as in the picture. Describe the curves that are rotated to generate this solid. 	
7: Draw the 3D solid of which the volume is given by: $V = \pi \int_0^1 (1-x^2)^2 \, dx$	

8: Give the formula for the area of the shaded region. Do not calculate the area



9: Given: $y = \sin x$ and $y = 1$

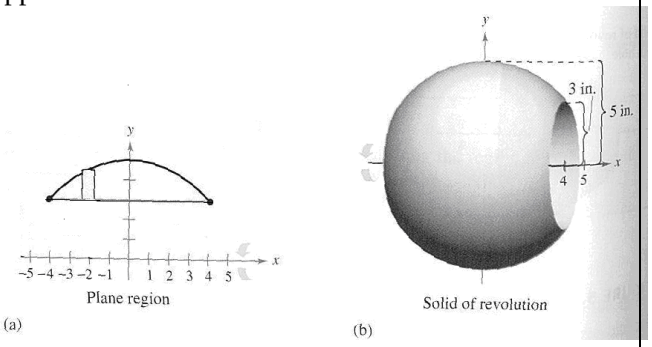
(i) Draw the graphs and shade the area bounded by the graphs and $x = 0$

(ii) Show the rotated area about the ***y*-axis** and the strip used to find the volume.

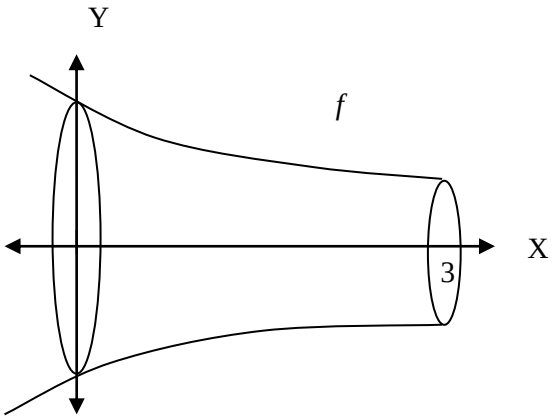
(iii) Write down a formula to find the volume when the region bounded by $y = \sin x$ and $y = 1$ is rotated about the ***y*-axis**. Do not calculate the volume.

10: Draw the 3D solid of which the volume is given by: $V = 2\pi \int_0^1 x(1-x^2)\ dx$

11: When the graph below is rotated, the solid on the right is generated. Show how you would cut the solid in appropriate shapes (discs, shells or washers) to approximate the volume of the solid.

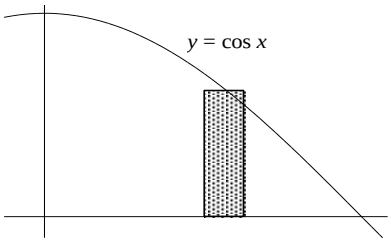


12: If the volume of the given solid of revolution is approximated by discs, sketch the discs that would give the volume: $\pi(f(0))^2 + \pi(f(1))^2 + \pi(f(2))^2$



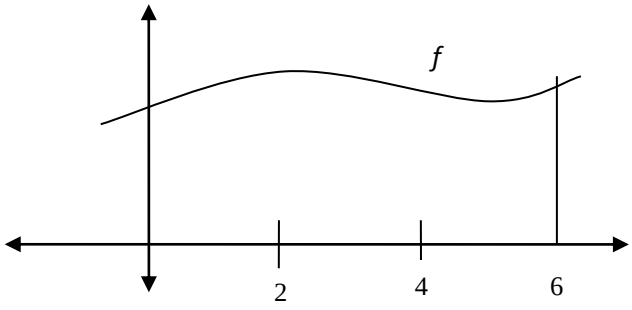
13. Represent $\int_0^1 (x - x^2)\, dx$; by a picture

14: Below the region bounded by the graph of $y = \cos x$, the *x*-axis and the *y*-axis is selected by the given strip. Give the formula for the volume generated when this area is rotated **about the *y*-axis.** Do not calculate the volume.

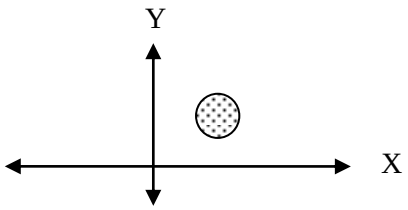
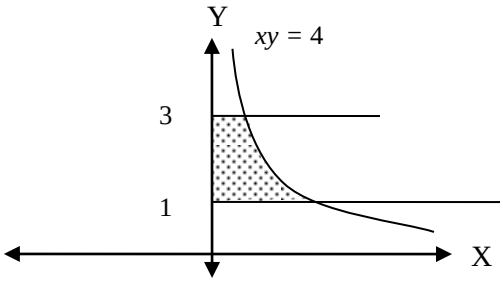
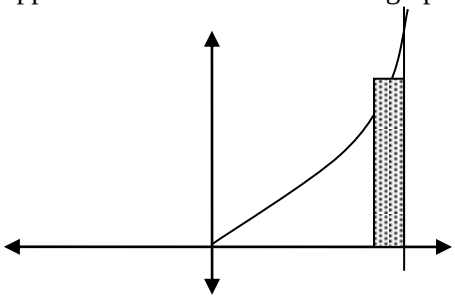


15: Show in terms of rectangles what the following represent with a sketch:

$2f(0) + 2f(2) + 2f(4)$

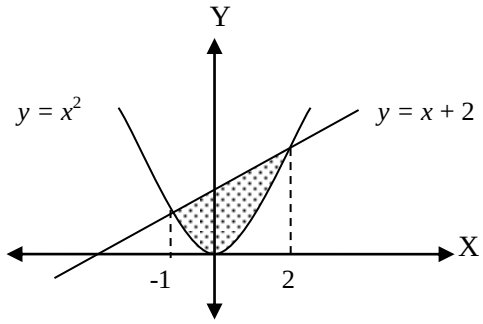
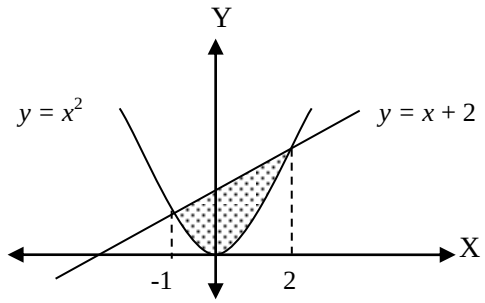


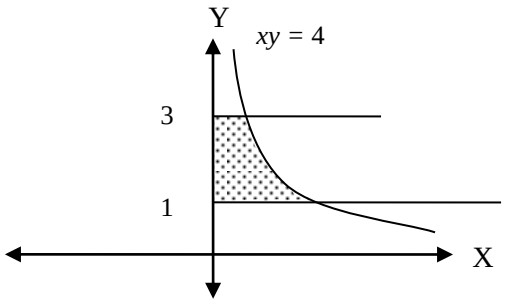
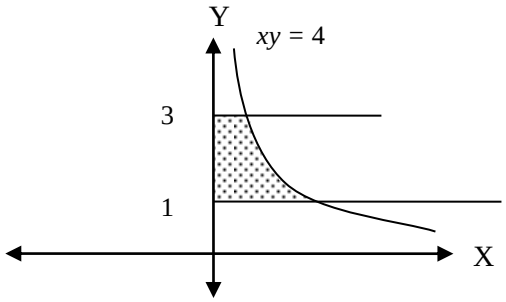
16: Calculate $\int_0^1 2\pi x(1 - \sin x)\, dx$

17: What solid do you get if you rotate the circle below about the ***y*-axis**? 	
18: Use integration methods to derive the formula for the volume of a cone of radius r and height h.	
19: Give a formula for the area of the shaded region. 	
20: Sketch four additional rectangles (similar to the given rectangle) so that the total area of the rectangles approximates the area under the graph. 	
21: Discuss how a hemisphere is generated as a solid of revolution.	

APPENDIX 3A: CHANGED INSTRUMENT

The questions were changed as follows from the pilot to the main study:

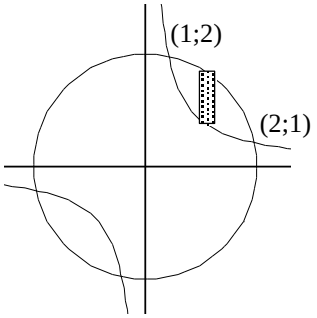
<table>
<tr><th>PILOT STUDY</th><th>MAIN STUDY</th></tr>
<tr><td></td><td>1. Graphing Skills</td></tr>
<tr><td>Was changed and modified from 5A
5A: Draw the solid that will be formed if a line with a positive gradient passing through the origin is rotated about the x-axis, where $x \in [0,3]$.</td><td>1 A: Draw a line with a positive gradient passing through the origin for $x \in [0,3]$ Changed</td></tr>
<tr><td>New question</td><td>1 B: Sketch the graphs and shade the first quadrant area bounded by $x^2 - y^2 = 9$ and $x = 5$ New</td></tr>
<tr><td>1. A LG ⟶ VS (2D)</td><td>2. A LG ⟶ VS (2D)</td></tr>
<tr><td>1A. Represent $x^2 + y^2 \leq 9$ by a picture.</td><td>2A: Represent $x^2 + y^2 \leq 9$ by a picture. Same</td></tr>
<tr><td>1B. Represent $\int_0^1 (x - x^2)\,dx$; by a picture</td><td>2B: Sketch the area represented by $\int_0^1 (x - x^2)\,dx$
Modified</td></tr>
<tr><td>2. VIS ⟶ ALG (2D)</td><td>3. VIS ⟶ ALG (2D)</td></tr>
<tr><td>2A. Give the formula for the area of the shaded region.
 
</td><td>3A: Substitute the equations of the given graphs in a suitable formula to represent the area of the shaded region.
 

Modified</td></tr>
<tr><td>2B. Give a formula for the area of the shaded region.
 
</td><td>3B: Substitute the equations of the given graphs in a suitable formula to represent the area of the shaded region.
 

Modified</td></tr>
<tr><td>3. A LG ⟶ VS (3D)</td><td>4. A LG ⟶ VS (3D)</td></tr>
<tr><td>3A: Draw the 3D solid of which the volume is given by
$V = \pi \int_0^1 (1 - x^2)^2\,dx$</td><td>4A: Draw the 3D solid of which the volume is given by V= $\pi \int_0^1 (1 - x)^2\,dx$ and show the representative strip.
Modified and made easier</td></tr>
<tr><td>3B: Draw the 3D solid of which the volume is given by
$V = 2\pi \int_0^1 x(1 - x^2)\,dx$</td><td>4B: Draw the 3D solid of which the volume is given by
V= $2\pi \int_0^1 x(1 - x^2)\,dx$ and show the representative strip.
Modified</td></tr>
</table>

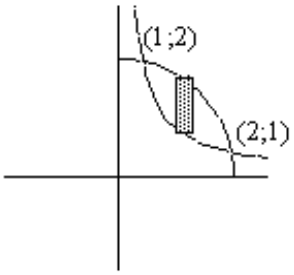
4. VIS → ALG (2D)

4A: Below the 1st quadrant area bounded by graphs of $x^2 + y^2 = 5$ and $xy = 2$ is selected using the given strip.
Give the formula for the volume generated if this area is rotated **about the *x*-axis.**
Do not calculate the volume.



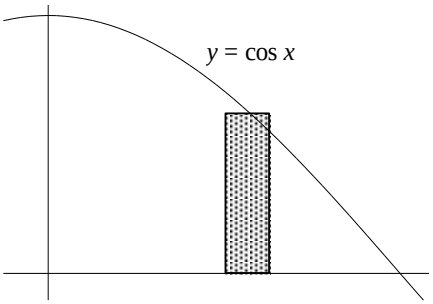
5. VIS → ALG (3D)

5A: The figure below represents the first quadrant area bounded by the graphs of $x^2 + y^2 = 5$ and $xy = 2$.
Using the selected strip, substitute the equations of the given graphs in a suitable formula to represent the volume generated if the selected area is rotated **about the *x*-axis.**
Do not calculate the volume.

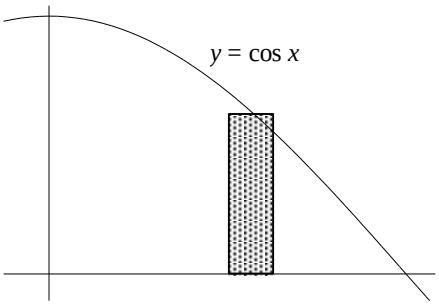


Modified

4B: Below the region bounded by the graph of $y = \cos x$, the *x*-axis and the *y*-axis is selected by the given strip. Give the formula for the volume generated when this area is rotated **about the *y*-axis.** Do not calculate the volume.



5B: The figure below represents the area bounded by the graphs of $y = \cos x$, the *x*-axis and the *y*-axis. Using the selected strip, substitute the equations of the given graphs in a suitable formula to represent the volume generated when this area is rotated **about the *y*-axis.** Do not calculate the volume.



Modified

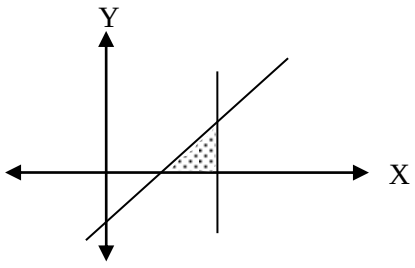
5. 2D → 3D

5A: Draw the solid that will be formed if a line with a positive gradient passing through the origin is rotated about the ***x*-axis**, where $x \in [0,3]$.

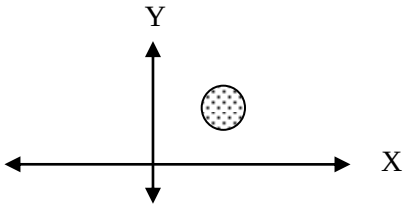
Changed to be 1A

6. 2D → 3D

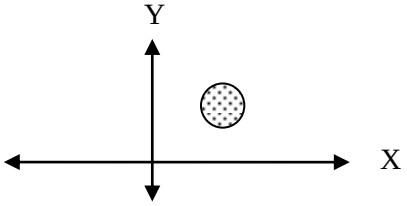
Changed to be 1A above for the main study and replaced by
6A: Draw the 3-dimensional solid that is generated when the shaded area below is rotated about the ***x*-axis.**



5B: What solid do you get if you rotate the circle below about the ***y*-axis**?



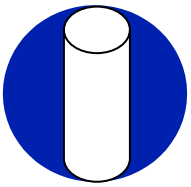
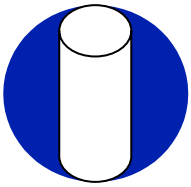
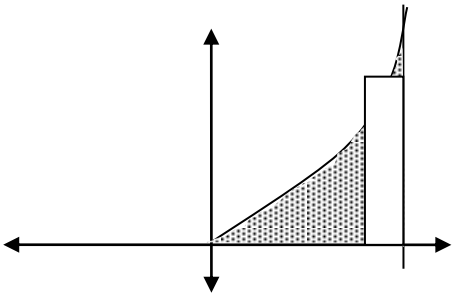
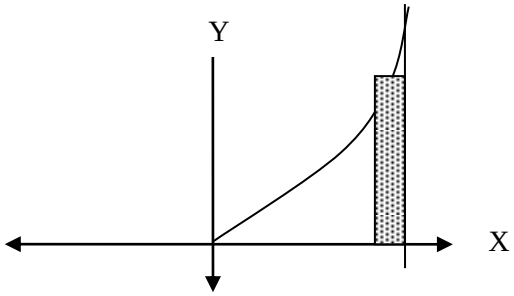
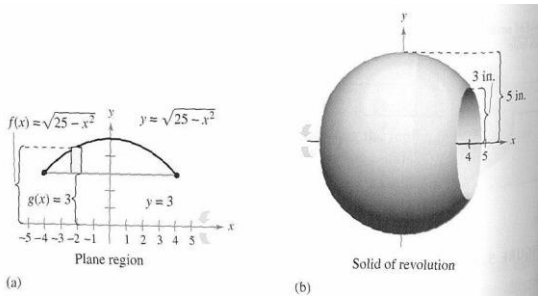
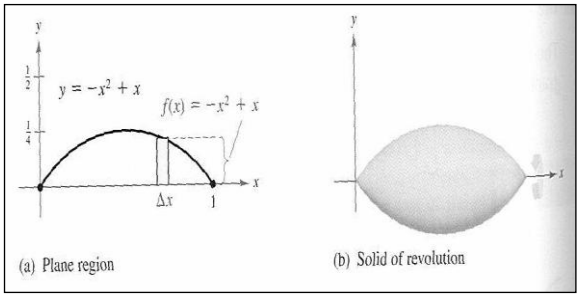
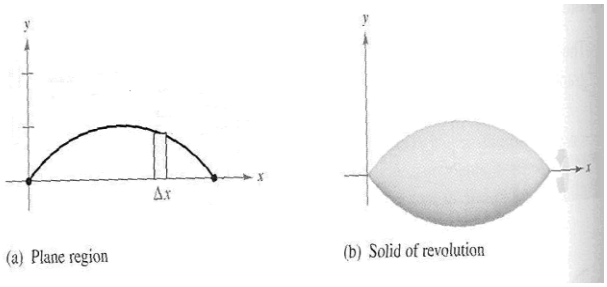
6 B: Draw a 3-dimensional solid that will be generated if you rotate the circle below about the ***y*-axis.**



Modified

6. 3D → 2D

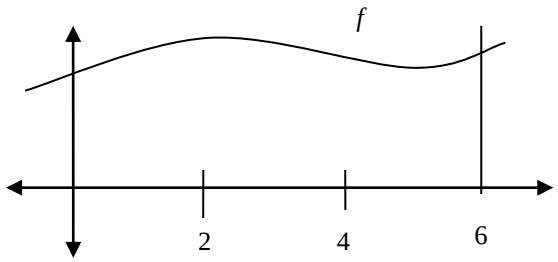
7. 3D → 2D

6 A: Discuss how a hemisphere is generated as a solid of revolution.	7 A: Sketch a graph that will generate half a sphere when rotated about the ***y***- axis. **Modified**
6 B: A hole with radius 2 cm is drilled through the centre of the sphere of radius 5 as in the picture. Describe the curves that are rotated to generate this solid. 	7 B: A hole is drilled through the centre of the sphere as in the picture. Sketch the graphs that were rotated to generate the solid as in the picture below.  **Modified**
7. CONTINUOUS ⟶ DISCRETE (VIS 2D)	**8. CONTINUOUS ⟶ DISCRETE (VIS) 2D and 3D**
7 A: Sketch three additional rectangles (similar to the given rectangle) so that the total area of the rectangles approximates the shaded area. 	8 A: Sketch three additional rectangular strips (similar to the given rectangle) so that the total area of the rectangles approximates the area under the graph.  **Modified**
8. CONTINUOUS ⟶ DISCRETE (VISL 3D)	
8A: When the graph below is rotated, the solid on the right is generated. Show how you would cut the solid in appropriate shapes (discs, shells or washers) to approximate the volume of the solid. 	**Removed**
8 B: When the graph below is rotated, the solid on the right is generated. Discuss how you would cut it to generate either (discs, shells or washers). 	8B: When the plane region (a) on the left is rotated, the 3-dimensional solid of revolution (b) on the right is generated. Show using diagrams how you would cut the solid of revolution (b) in appropriate shapes (discs, shells or washers) to approximate its volume.  **Modified**

9. {DISCRT → CONTNS and CONTS → DISCRT } (ALG)

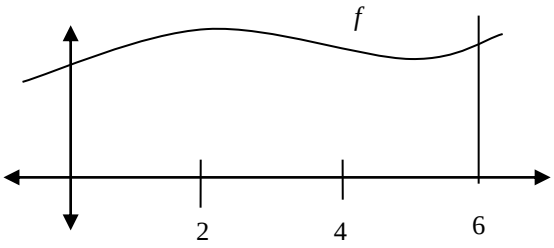
9 A: Show what the following represent with a sketch.

$2f(0)+2f(2)+2f(4)$



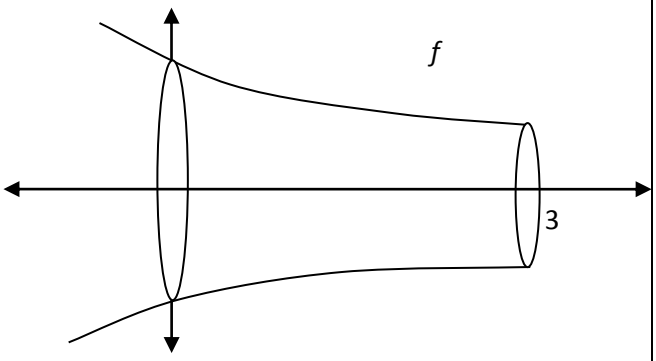
9 A: Show in terms of rectangles what the following represent with a sketch:

$2f(0)+2f(2)+2f(4)$

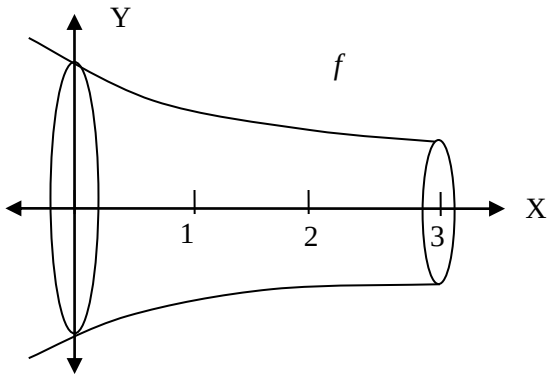


Modified

9 B: If the volume of the given solid of revolution is approximated by discs, sketch the discs that would give the volume. $\pi(f(0))^2+\pi(f(1))^2+\pi(f(2))^2$



9 B: If the volume of the given solid of revolution is approximated by discs, sketch the discs that would give the volume: $\pi(f(0))^2+\pi(f(1))^2+\pi(f(2))^2$



Same

10. GENERAL MANIPULATION SKILLS

10 A: Calculate the point of intersection of

$4x^2+9y^2=36$ and $2x+3y=6$ **Added**

10 A: Calculate $\int_0^1 \pi(1-x^2)^2\,dx$

10 B: Calculate $\int_0^1 2\pi x(1-\sin x)\,dx$

10B : Calculate $\int_0^1 \pi(1-x^2)^2\,dx$ **Same**

10 C: Calculate $\int_0^1 2\pi x(1-\sin x)\,dx$ **Same**

11. COGNITIVE SKILLS

11 A: Given the graphs of $y=\sin x$ and $y=1$

(i) Draw the graphs and shade the area bounded by the graphs and $x = 0$

(ii) Show the rotated area about the ***y*-axis** and the strip used

(iii)Write down a formula to find the volume when the region between $y=\sin x$ and $y=1$ is rotated about the ***y*-axis**.

11 A: Given: $y=\sin x$, where $x\in\left[0,\frac{\pi}{2}\right]$ and $y=1$

(i) Sketch the graphs and shade the area bounded by the graphs and $x = 0$

(ii) Show the rotated area about the ***y*-axis** and the representative strip to be used to calculate the volume generated.

(iii) Calculate the volume generated when this area is rotated **about the *y*-axis.** **Modified**

11 B: Use integration methods to derive the formula of a volume of a cone of radius *r* and height *h*.

11 B: Use integration methods to show that the volume of a cone of radius *r* and height *h* is given by $\frac{1}{3}\pi r^2 h$.

Modified

APPENDIX 3B: MAIN INSTRUMENT ADMINISTERED

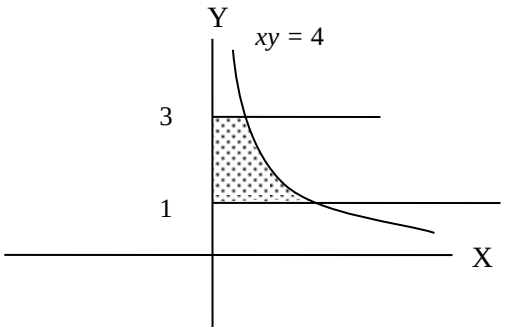
Data collecting Instrument for VSOR: Administered

March, 2007 **Researcher: Mofolo BLK**

SECTION A

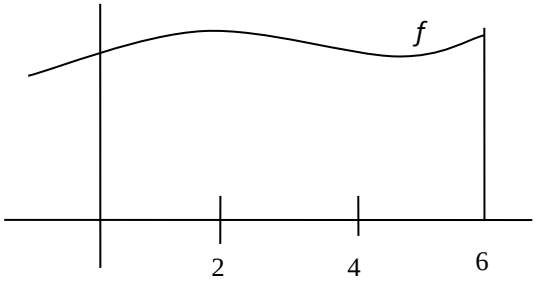
1. Draw the 3D solid of which the volume is given by $V = 2\pi\int_0^1 x(1-x^2)\,dx$ and show the representative strip.	
2. Calculate the point of intersection of $4x^2+9y^2=36$ and $2x+3y=6$	
3. Sketch the graphs and shade the first quadrant area bounded by $x^2-y^2=9$ and $x=5$	
4. Calculate $\int_0^1 2\pi x(1-\sin x)\,dx$	
5. Sketch a graph that will generate half a sphere when rotated about the ***y***- axis.	

6. Substitute the equations of the given graphs in a suitable formula to represent the area of the shaded region.

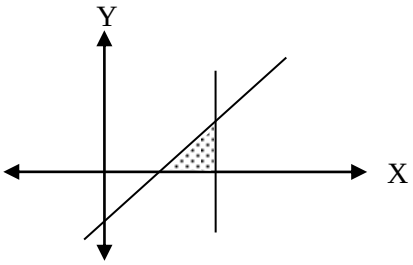


7. Show in terms of rectangles what the following represent with a sketch:

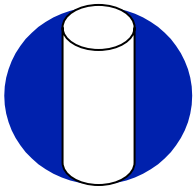
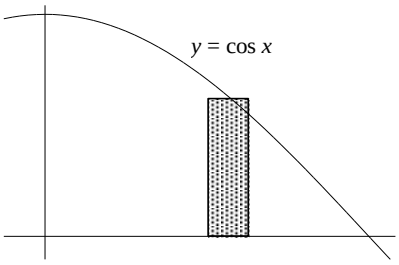
$2f(0)+2f(2)+2f(4)$

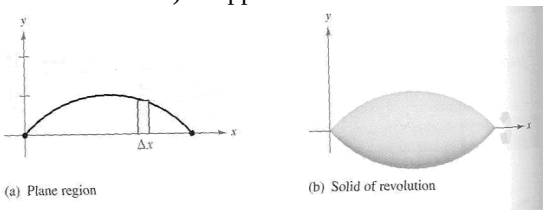


8. Draw the 3-dimensional solid that is generated when the shaded area below is rotated about the ***x*-axis.**



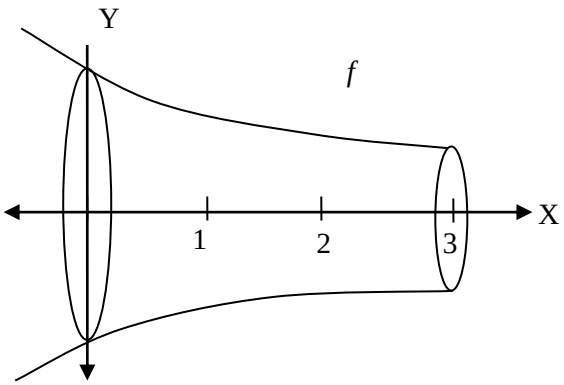
SECTION B

9. Sketch the area represented by $\int_0^1 (x - x^2)\, dx$	
10. A hole is drilled through the centre of the sphere as in the picture. Sketch the graphs that were rotated to generate the solid as in the picture below. 	
11. Given: $y = \sin x$, where $x \in \left[0\,,\frac{\pi}{2}\right]$ and $y = 1$ (i) Sketch the graphs and shade the area bounded by the graphs and $x = 0$ (ii) Show the rotated area about the ***y*-axis** and the representative strip to be used to calculate the volume generated. (iii) Calculate the volume generated when this area is rotated **about the *y*-axis.**	
12. Draw a line with a positive gradient passing through the origin for $x \in [0,3]$	
13. The figure below represents the area bounded by the graphs of $y = \cos x$, the x-axis and the y-axis. Using the selected strip, substitute the equations of the given graphs in a suitable formula to represent the volume generated when this area is rotated **about the *y*-axis.** Do not calculate the volume. 	

14. When the plane region (a) on the left is rotated, the 3-dimensional solid of revolution (b) on the right is generated. Show using diagrams how you would cut the solid of revolution (b) in appropriate shapes (discs, shells or washers) to approximate its volume.  (a) Plane region (b) Solid of revolution	
15. Draw the 3D solid of which the volume is given by $V = \pi \int_0^1 (1-x)^2 \, dx$ and show the representative strip.	
16. Calculate $\int_0^1 \pi (1-x^2)^2 \, dx$	

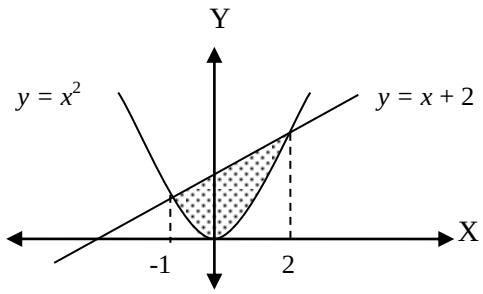
SECTION C

17. If the volume of the given solid of revolution is approximated by discs, sketch the discs that would give the volume: $\pi(f(0))^2 + \pi(f(1))^2 + \pi(f(2))^2$

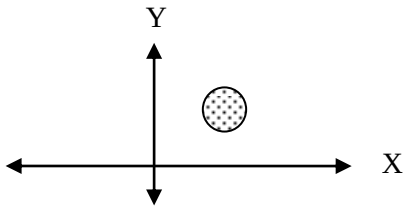


18. Use integration methods to show that the volume of a cone of radius r and height h *is* given by $\frac{1}{3}\pi r^2 h$.

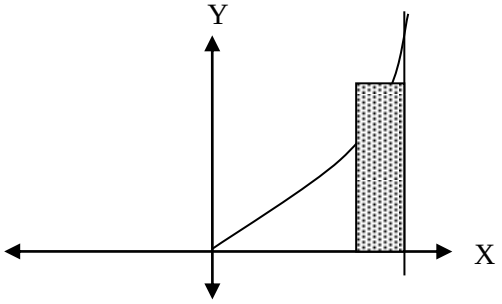
19. Substitute the equations of the given graphs in a suitable formula to represent the area of the shaded region.

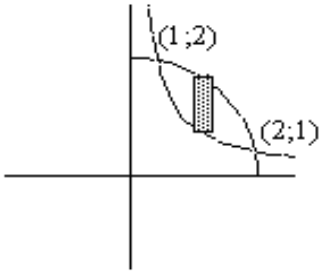


20. Draw a 3-dimensional solid that will be generated if you rotate the circle below about the ***y*-axis.**



21. Sketch three additional rectangular strips (similar to the given rectangle) so that the total area of the rectangles approximates the area under the graph.



22. Represent $x^2 + y^2 \leq 9$ by a picture.	
23. The figure below represents the first quadrant area bounded by the graphs of $x^2 + y^2 = 5$ and $xy = 2$. Using the selected strip, substitute the equations of the given graphs in a suitable formula to represent the volume generated if the selected area is rotated **about the *x*-axis.** Do not calculate the volume.  	

APPENDIX 4A: MAIN RESULTS FOR THE QUESTIONNARE 1st RUN

College	Students	1A	1B	2A	2B	3A	3B	4A	4B	5A	5B	6A	6B	7A	7B	8A	8B	9A	9B	10A	10B	10C	11A	11B
		ELM1		ELM2		ELM3		ELM4		ELM5		ELM6		ELM7		ELM8		ELM9		ELM10			ELM11	
		GR		AV2D		VA2D		AV3D		VA3D		2D-3D		3D-2D		CD(V)		DC-CD(A)		GMNP			CGLCD	
B	1	NU	AC	AC	FC	FC	FC	ND	FC	AC	AC	FC	FC	FC	FC	FC	ND	AC	TU	NU	ND	AC	AC	ND
B	2	FC	FC	AC	NU	FC	FC	AC	AC	AC	FC	FC	ND	FC	NU	TU	TU	NU	TU	FC	FC	AC	AC	AC
B	3	NU	FC	TU	TU	AC	FC	ND	AC	FC	ND	NU	NU	FC	ND	TU	ND	ND	NU	FC	ND	NU	TU	ND
B	4	NU	TU	AC	AC	FC	TU	NU	AC	AC	NU	FC	TU	FC	TU	TU	FC	TU	TU	NU	ND	ND	TU	NU
B	5	NU	AC	AC	TU	FC	FC	NU	AC	FC	NU	TU	FC	AC	TU	TU	TU	AC	TU	NU	ND	TU	TU	NU
B	6	ND	AC	AC	AC	FC	FC	AC	AC	FC	NU	FC	FC	FC	TU	TU	TU	NU	TU	NU	ND	AC	AC	AC
B	7	NU	AC	AC	AC	FC	AC	NU	AC	AC	NU	NU	ND	FC	ND	NU	ND	ND	TU	FC	NU	AC	TU	ND
B	8	ND	AC	AC	FC	FC	FC	ND	AC	FC	ND	FC	AC	FC	ND	TU	ND	ND	TU	FC	ND	AC	ND	AC
B	9	NU	FC	AC	NU	FC	TU	NU	AC	FC	NU	TU	NU	TU	TU	NU	TU	NU	NU	FC	FC	NU	TU	NU
B	10	NU	AC	AC	AC	FC	AC	NU	AC	FC	NU	ND	NU	FC	NU	AC	NU	NU	NU	FC	AC	AC	TU	NU
B	11	ND	AC	AC	FC	FC	FC	ND	AC	FC	ND	FC	NU	FC	ND	NU	ND	NU	ND	FC	ND	AC	TU	NU
B	12	ND	FC	AC	NU	FC	TU	ND	FC	FC	ND	FC	NU	FC	ND	AC	ND	NU	ND	AC	AC	AC	TU	NU
B	13	NU	AC	AC	FC	FC	AC	ND	FC	FC	FC	AC	NU	TU	ND	AC	ND	TU	ND	NU	FC	AC	TU	NU
B	14	AC	TU	AC	FC	FC	TU	ND	NU	TU	NU	FC	NU	FC	ND	FC	ND	ND	ND	NU	FC	AC	TU	NU
B	15	FC	FC	AC	NU	FC	FC	AC	TU	FC	FC	FC	NU	FC	TU	FC	FC	FC	TU	NU	FC	AC	AC	TU
B	16	FC	AC	AC	FC	FC	NU	AC	TU	AC	AC	NU	NU	AC	TU	NU	NU	ND	TU	AC	AC	AC	TU	NU
B	17	NU	TU	AC	FC	FC	NU	AC	TU	FC	AC	NU	NU	NU	TU	NU	AC	NU	TU	FC	FC	AC	TU	TU
B	18	AC	NU	AC	AC	AC	ND	NU	TU	FC	NU	ND	AC	NU	TU	TU	TU	ND	NU	NU	FC	AC	TU	ND
B	19	NU	AC	AC	FC	FC	NU	AC	TU	FC	NU	NU	NU	NU	TU	NU	TU	NU	TU	FC	FC	AC	TU	AC
B	20	NU	NU	AC	AC	TU	NU	NU	TU	NU	NU	ND	NU	NU	TU	NU	TU	NU	TU	AC	AC	AC	TU	ND
A	21	FC	TU	AC	FC	NU	FC	FC	NU	FC	FC	FC	TU	NU	FC	FC	TU	ND	NU	NU	FC	AC	AC	FC
A	22	AC	NU	AC	AC	FC	FC	AC	AC	AC	ND	ND	TU	FC	NU	TU	ND	ND	ND	NU	FC	TU	TU	ND
A	23	AC	TU	TU	TU	FC	TU	ND	ND	FC	NU	ND	NU	FC	ND	TU	ND	ND	ND	NU	NU	AC	NU	NU
A	24	ND	FC	AC	NU	FC	FC	FC	FC	NU	AC	FC	NU	FC	TU	FC	TU	NU	TU	NU	FC	TU	AC	NU
A	25	NU	FC	FC	AC	TU	NU	ND	ND	FC	NU	FC	TU	FC	AC	FC	ND	ND	NU	NU	ND	AC	TU	NU
A	26	NU	FC	FC	ND	FC	NU	ND	AC	FC	NU	FC	TU	FC	FC	FC	TU	ND	NU	NU	ND	AC	TU	NU
A	27	ND	NU	AC	NU	FC	FC	NU	AC	FC	NU	NU	NU	AC	ND	NU	NU	ND	ND	NU	TU	TU	NU	ND
A	28	NU	NU	NU	FC	FC	TU	NU	TU	NU	NU	NU	NU	FC	NU	NU	TU	ND	TU	FC	NU	FC	TU	NU
A	29	NU	FC	AC	NU	FC	FC	FC	TU	TU	AC	FC	TU	NU	AC	FC	TU	NU	TU	TU	AC	TU	TU	NU
A	30	ND	NU	TU	NU	FC	TU	NU	AC	TU	NU	ND	ND	NU	TU	TU	NU	ND	TU	NU	NU	NU	NU	NU
A	31	NU	TU	FC	FC	FC	AC	NU	AC	FC	NU	ND	TU	FC	TU	TU	NU	ND	NU	NU	FC	TU	TU	NU
A	32	AC	TU	AC	FC	FC	FC	FC	AC	FC	NU	FC	NU	FC	TU	TU	ND	NU	TU	NU	AC	AC	TU	ND
A	33	ND	NU	TU	TU	FC	FC	ND	TU	FC	ND	ND	TU	ND	ND	TU	ND	ND	ND	ND	AC	TU	ND	ND
A	34	AC	NU	AC	NU	FC	FC	AC	AC	FC	ND	NU	TU	AC	ND	TU	ND	ND	NU	NU	FC	TU	TU	ND
A	35	ND	NU	AC	NU	FC	NU	TU	TU	TU	ND	ND	NU	ND	ND	NU	NU	ND	ND	NU	TU	TU	NU	ND
A	36	ND	TU	ND	FC	TU	NU	TU	ND	TU	ND	ND	NU	ND	ND	ND	ND	ND	ND	NU	FC	AC	ND	ND
A	37	NU	NU	AC	ND	FC	TU	TU	AC	FC	AC	ND	TU	FC	ND	TU	ND	ND	ND	NU	FC	FC	TU	ND

APPENDIX 4B: OVERALL RESPONSE PERCENTAGE PER SKILL FACTOR

(i) Skill factor I

	Q1A	Q1B	Q2A	Q2B	Q3A	Q3B	Q4A	Q4B	Q5A	Q5B	Σ	%	%
FC	4	9	3	13	31	16	4	4	23	4	111	**30.0**	**55.9**
AC	6	10	28	8	2	4	8	18	6	6	96	**25.9**	
TU	0	8	4	4	3	8	3	10	5	0	45	**12.2**	**44.1**
NU	17	10	1	10	1	8	11	2	3	18	81	**21.9**	
ND	10	0	1	2	0	1	11	3	0	9	37	**10.0**	
Σ	**37**	**37**	**37**	**37**	**37**	**37**	**37**	**37**	**37**	**37**	**370**	**100**	

(ii) Skill factor II

	Q6A	Q6B	Q7A	Q7B	Σ	%	%
FC	15	3	21	3	42	**28.4**	**34.5**
AC	1	2	4	2	9	**6.1**	
TU	2	10	2	14	28	**18.9**	**65.5**
NU	8	19	7	4	38	**25.7**	
ND	11	3	3	14	31	**20.9**	
Σ	**37**	**37**	**37**	**37**	**148**	**100**	

(iii) Skill factor III

	Q8A	Q8B	Q9A	Q9B	Σ	%	%
FC	8	2	1	0	11	**7.4**	**11.5**
AC	3	1	2	0	6	**4.1**	
TU	15	12	2	17	46	**31.1**	**88.5**
NU	10	6	12	9	37	**25.0**	
ND	1	16	20	11	48	**32.4**	
	37	**37**	**37**	**37**	**148**	**100**	

(iv) Skill factor IV

	Q10A	Q10B	Q10C		Σ	%	%
FC	10	15	2	FC	27	**24.3**	**53.1**
AC	3	7	22	AC	32	**28.8**	
TU	1	2	9	TU	12	**10.8**	**46.9**
NU	22	4	3	NU	29	**26.1**	
ND	1	9	1	ND	11	**9.9**	
Σ	**37**	**37**	**37**	**37**	**111**	**100**	

(v) Skill factor V

	Q11A	Q11B	Σ	%	%
FC	0	1	1	**1.4**	**14.9**
AC	6	4	10	**13.5**	
TU	24	2	26	**35.1**	**85.1**
NU	4	17	21	**28.4**	
ND	3	13	16	**21.6**	
	37	**37**	**74**	**37**	

APPENDIX 4C: AVERAGE SCORES PER ELEMENT FROM THE QUESTIONNARE 1st RUN

		ELM1	ELM2	ELM3	ELM4	ELM5	ELM6	ELM7	ELM8	ELM9	ELM10	ELM11
College	Students	GR	AV2D	VA2D	AV3D	VA3D	2D-3D	3D-2D	CD(V)	DC-CD(A)	GMNP	CGLCD
B	1	2	3.5	4	2	3	4	4	2	2.5	1.5	1.5
B	2	4	2	4	3	3.5	2	2.5	2	1.5	3.5	3
B	3	2.5	2	3.5	1.5	2	1	2	1	0.5	0.5	1
B	4	1.5	3	3	2	2	3	3	3	2	0	1.5
B	5	2	2.5	4	2	2.5	3	2.5	2	2.5	1	1.5
B	6	1.5	3	4	3	2.5	4	3	2	1.5	1.5	3
B	7	2	3	3.5	2	2	0.5	2	0.5	1	2	1
B	8	1.5	3.5	4	1.5	2	3.5	2	1	1	1.5	1.5
B	9	2.5	2	3	2	2.5	1.5	2	1.5	1	2.5	1.5
B	10	2	3	3.5	2	2.5	0.5	2.5	2	1	3	1.5
B	11	1.5	3.5	4	1.5	2	2.5	2	0.5	0.5	1.5	1.5
B	12	2	2	3	2	2	2.5	2	1.5	0.5	3	1.5
B	13	2	3.5	3.5	2	4	2	1	1.5	1	3.5	1.5
B	14	2.5	3.5	3	0.5	1.5	2.5	2	2	0	3.5	1.5
B	15	4	2	4	2.5	4	2.5	3	4	3	3.5	2.5
B	16	3.5	3.5	2.5	2.5	3	1	2.5	1	1	3	1.5
B	17	1.5	3.5	2.5	2.5	3.5	1	1.5	2	1.5	3.5	2
B	18	2	3	1.5	1.5	2.5	1.5	1.5	2	0.5	3.5	1
B	19	2	3.5	2.5	2.5	2.5	1	1.5	1.5	1.5	3.5	2.5
B	20	1	3	1.5	1.5	1	0.5	1.5	1.5	1.5	3	1
A	1	3	3.5	2.5	2.5	4	3	2.5	3	0.5	3.5	3.5
A	2	2	3	4	3	1.5	1	2.5	1	0	3	1
A	3	2.5	2	3	0	2.5	0.5	2	1	0	2	1
A	4	2	2	4	4	2	2.5	3	3	1.5	3	2
A	5	2.5	3.5	1.5	0	2.5	3	3.5	2	0.5	1.5	1.5
A	6	2.5	2	2.5	1.5	2.5	3	4	3	0.5	1.5	1.5
A	7	0.5	2	4	2	2.5	1	1.5	1	0	2	0.5
A	8	1	2.5	3	1.5	1	1	2.5	1.5	1	2.5	1.5
A	9	2.5	2	4	3	2.5	3	2	3	1.5	2.5	1.5
A	10	0.5	1.5	3	2	1.5	0	1.5	1.5	1	1	1
A	11	1.5	4	3.5	2	2.5	1	3	1.5	0.5	3	1.5
A	12	2.5	3.5	4	3.5	2.5	2.5	3	1	1.5	3	1
A	13	0.5	2	4	1	2	1	0	1	0	2.5	0
A	14	2	2	4	3	2	1.5	1.5	1	0.5	3	1
A	15	0.5	2	2.5	2	1	0.5	0	1	0	2	0.5
A	16	1	2	1.5	1	1	0.5	0	0	0	3.5	0
A	17	1	1.5	3	2.5	3.5	1	2	1	0	4	1

APPENDIX 4D: SKILL FACTORS PERCENTAGE OF RESPONSES AND PROCEDURAL AND CONCEPTUAL CLASSIFICATION

(i) Responses for Skill factor I & V: Procedural and conceptual questions

	Q1A	Q1B	Q2A	Q2B	Q3A	Q3B	Q4A	Q4B	Q5A	Q5B	Q11A	Q11B	Σ	%	%
FC	4	9	3	13	31	16	4	4	23	4	0	1	112	**25.2**	**49.1**
AC	6	10	28	8	2	4	8	18	6	6	6	4	106	**23.9**	
TU	0	8	4	4	3	8	3	10	5	0	24	2	71	**16.0**	**50.9**
NU	17	10	1	10	1	8	11	2	3	18	4	17	102	**23.0**	
ND	10	0	1	2	0	1	11	3	0	9	3	13	53	**11.9**	
Σ	**37**	**37**	**37**	**37**	**37**	**37**	**37**	**37**	**37**	**37**	**37**	**37**	**444**	**100**	

(ii) Responses for Skill factor II & III: Conceptual

	Q6A	Q6B	Q7A	Q7B	Q8A	Q8B	Q9A	Q9B	Q9B	Σ	%	%
FC	15	3	21	3	8	2	1	0	0	53	**17.9**	**23**
AC	1	2	4	2	3	1	2	0	0	15	**5.1**	
TU	2	10	2	14	15	12	2	17	17	74	**25.0**	**77**
NU	8	19	7	4	10	6	12	9	9	75	**25.3**	
ND	11	3	3	14	1	16	20	11	11	79	**26.7**	
Σ	**37**	**37**	**37**	**37**	**37**	**37**	**37**	**37**		**296**	**100**	

(iii) Responses for Skill factor IV: Procedural

	Q10A	Q10B	Q10C	Σ	%	%
FC	10	15	2	27	**24.3**	**53.1**
AC	3	7	22	32	**28.8**	
TU	1	2	9	12	**10.8**	**46.9**
NU	22	4	3	29	**26.1**	
ND	1	9	1	11	**9.9**	
Σ	**37**	**37**	**37**	**111**	**100**	

APPENDIX 5A: MAIN RESULTS FOR THE QUESTIONNAIRE 2 RUN (Test 1 & 2)

College	Students	Q1A	Q1B	Q2B	Q3B	Q4A	Q4B	Q5B	Q6A	Q7A	Q7B	Q8B	Q9A	Q10A	Q10B	Q10C	Q1
B	1	NU	FC	TU	FC	ND	NU	ND	NU	NU	NU	ND	ND	NU	TU	NU	NU
B	2	ND	FC	AC	FC	ND	NU	ND	ND	NU	ND	ND	ND	NU	TU	TU	TU
B	3	NU	NU	NU	TU	ND	NU	NU	NU	NU	NU	ND	NU	NU	FC	NU	NU
B	4	NU	TU	AC	FC	ND	ND	AC	NU	FC	ND	TU	TU	NU	ND	NU	NU
B	5	NU	TU	FC	FC	NU	ND	TU	NU	FC	FC	TU	TU	NU	FC	NU	TU
B	6	NU	FC	ND	FC	TU	ND	NU	NU	ND	FC	ND	AC	ND	TU	TU	AC
B	7	TU	NU	ND	NU	TU	NU	NU	TU	ND	NU	TU	ND	NU	TU	TU	NU
B	8	TU	NU	NU	FC	ND	NU	ND	TU	FC	TU	TU	ND	NU	FC	TU	TU
B	9	NU	FC	FC	FC	NU	NU	AC	TU	TU	ND	ND	ND	FC	FC	AC	NU
B	10	TU	FC	FC	FC	NU	NU	TU	TU	AC	TU	NU	ND	NU	AC	AC	TU
B	11	NU	FC	NU	TU	NU	NU	FC	NU	NU	TU	NU	AC	NU	FC	TU	TU
B	12	NU	FC	NU	NU	ND	ND	TU	ND	ND	TU	ND	TU	ND	AC	NU	TU
B	13	NU	FC	TU	TU	ND	NU	ND	ND	ND	ND	ND	TU	NU	ND	NU	TU
B	14	NU	FC	NU	FC	TU	NU	FC	TU	FC	NU	NU	NU	NU	TU	TU	TU
B	15	TU	FC	NU	FC	ND	NU	FC	NU	TU	NU	ND	ND	NU	FC	TU	TU
B	16	AC	TU	TU	FC	NU	AC	AC	NU	TU	TU	ND	ND	NU	AC	TU	NU
B	17	NU	FC	FC	TU	TU	NU	AC	NU	FC	NU	ND	TU	NU	FC	TU	TU
B	18	ND	NU	NU	NU	ND	ND	FC	ND	AC	ND	ND	ND	NU	AC	TU	NU
B	19	AC	AC	TU	TU	ND	ND	AC	ND	ND	ND	ND	ND	TU	ND	AC	TU
B	20	NU	AC	TU	AC	ND	NU	NU	NU	NU	NU	ND	ND	NU	ND	NU	TU
B	21	NU	NU	TU	AC	ND	NU	NU	NU	NU	TU	ND	NU	NU	ND	NU	NU
B	22	NU	FC	TU	FC	NU	NU	NU	NU	NU	NU	TU	NU	NU	FC	TU	NU
B	23	NU	TU	NU	TU	NU	NU	NU	AC	FC	NU	TU	NU	FC	NU	AC	TU
B	24	NU	FC	TU	TU	ND	AC	TU	NU	AC	TU	NU	AC	NU	AC	NU	TU
B	25	NU	FC	NU	TU	NU	AC	FC	ND	TU	TU	ND	ND	NU	FC	FC	AC
B	26	TU	FC	AC	NU	TU	AC	NU	AC	FC	NU	NU	AC	AC	AC	AC	NU
B	27	NU	TU	TU	FC	NU	NU	NU	NU	FC	ND	NU	NU	NU	TU	TU	NU
B	28	NU	TU	AC	TU	NU	NU	NU	NU	NU	NU	NU	NU	NU	FC	AC	NU
B	29	AC	AC	TU	TU	ND	ND	FC	NU	NU	ND	ND	ND	ND	FC	NU	TU
B	30	NU	FC	NU	TU	NU	NU	NU	NU	NU	NU	NU	NU	NU	FC	AC	NU
B	31	FC	TU	NU	TU	ND	NU	TU	NU	NU	ND	ND	TU	NU	FC	NU	NU
B	32	NU	NU	NU	NU	NU	NU	NU	AC	NU	NU	NU	NU	NU	AC	NU	NU
B	33	AC	NU	NU	TU	NU	NU	NU	NU	NU	NU	NU	TU	NU	FC	NU	NU
B	34	NU	FC	NU	TU	NU	NU	NU	NU	NU	TU	TU	TU	NU	NU	AC	TU
B	35	NU	FC	AC	FC	ND	NU	ND	ND	NU	TU	ND	ND	NU	AC	TU	TU
B	36	NU	AC	TU	FC	TU	NU	TU	NU	NU	TU	NU	AC	NU	NU	NU	TU
B	37	TU	FC	AC	FC	ND	NU	NU	ND	NU	TU	ND	NU	NU	NU	AC	TU
B	38	NU	AC	TU	FC	TU	NU	AC	NU	NU	TU	NU	TU	NU	FC	NU	TU
B	39	NU	FC	TU	FC	NU	NU	TU	NU	NU	TU	NU	TU	NU	FC	NU	TU
B	40	NU	NU	AC	FC	ND	NU	NU	ND	NU	NU	ND	ND	NU	AC	NU	TU
B	41	NU	TU	NU	TU	NU	NU	ND	ND	NU	TU	ND	ND	NU	FC	TU	NU
B	42	AC	AC	AC	FC	ND	NU	AC	NU	FC	ND	ND	NU	NU	ND	AC	TU
B	43	AC	TU	AC	TU	ND	NU	AC	NU	NU	TU	ND	ND	NU	ND	AC	TU
B	44	TU	FC	TU	NU	NU	TU	FC	NU	AC	TU	NU	NU	FC	TU	TU	TU
B	45	NU	AC	TU	FC	ND	AC	FC	TU	ND	ND	ND	ND	FC	ND	AC	TU

B	46	AC	FC	NU	FC	ND	[illegible]	[illegible]	[illegible]	ND	ND	ND	TU	NU	ND	NU	TU
B	47	TU	NU	NU	TU	NU	ND	NU	NU	NU	ND	ND	ND	NU	FC	NU	NU
B	48	NU	FC	NU	FC	TU	NU	AC	NU	TU	TU	ND	ND	NU	AC	NU	NU
B	49	TU	FC	AC	FC	NU	NU	FC	NU	TU	NU	ND	NU	NU	AC	TU	TU
B	50	ND	FC	AC	TU	ND	NU	ND	ND	FC	ND	ND	ND	NU	ND	FC	ND
B	51	NU	FC	TU	FC	NU	NU	NU	NU	FC	TU	ND	ND	NU	FC	NU	TU
B	52	ND	AC	TU	FC	ND	NU	ND	ND	FC	NU	ND	ND	ND	ND	NU	NU
B	53	NU	TU	NU	TU	NU	NU	AC	NU	FC	NU	TU	NU	NU	TU	TU	TU
B	54	NU	FC	FC	FC	TU	NU	AC	TU	FC	NU	NU	TU	NU	NU	TU	TU
B	55	NU	FC	AC	NU	NU	NU	NU	NU	FC	NU	ND	NU	NU	AC	FC	TU
B	56	TU	FC	NU	TU	TU	AC	NU	NU	NU	TU	TU	ND	NU	AC	AC	TU
B	57	TU	TU	NU	TU	ND	NU	NU	AC	ND	TU	ND	TU	NU	AC	NU	NU
B	58	NU	FC	NU	FC	ND	NU	NU	TU	NU	TU	ND	TU	NU	FC	AC	TU
B	59	NU	FC	AC	TU	TU	TU	AC	NU	ND	TU	ND	ND	NU	TU	NU	TU
B	60	TU	FC	AC	AC	NU	NU	FC	NU	FC	NU	ND	NU	NU	ND	AC	TU
B	61	TU	FC	TU	FC	NU	AC	TU	NU	TU	TU	ND	NU	NU	TU	FC	TU
B	62	NU	FC	TU	AC	NU	NU	AC	NU	NU	TU	NU	NU	NU	FC	NU	TU
B	63	NU	FC	TU	AC	NU	NU	FC	NU	NU	TU	NU	NU	NU	TU	TU	TU
B	64	TU	TU	NU	TU	TU	TU	AC	NU	ND	ND	NU	ND	NU	FC	NU	ND
B	65	TU	NU	NU	NU	ND	ND	NU	NU	NU	ND	ND	ND	ND	FC	NU	NU
B	66	TU	NU	FC	AC	NU	NU	NU	AC	NU	NU	ND	ND	NU	FC	NU	NU
B	67	FC	NU	NU	TU	NU	ND	NU	NU	NU	ND	TU	AC	NU	FC	NU	NU
B	68	ND	NU	NU	TU	ND	ND	NU	NU	ND	ND	ND	ND	NU	FC	NU	NU
B	69	TU	NU	AC	TU	NU	ND	NU	NU	ND	ND	ND	ND	NU	AC	NU	NU
B	70	TU	NU	NU	TU	NU	AC	NU	TU	NU	NU	NU	TU	NU	AC	NU	NU
B	71	TU	NU	NU	ND	NU	NU	NU	TU	NU	ND	ND	NU	NU	FC	NU	NU
B	72	ND	FC	NU	TU	NU	NU	AC	ND	AC	NU	NU	ND	NU	ND	AC	TU
B	73	NU	FC	NU	TU	NU	NU	TU	NU	FC	ND	ND	ND	NU	NU	NU	TU
B	74	NU	FC	TU	TU	ND	NU	FC	NU	FC	AC	NU	TU	NU	FC	AC	NU
B	75	TU	NU	NU	TU	NU	NU	NU	ND	NU	NU	NU	ND	NU	FC	NU	NU
B	76	TU	NU	AC	TU	NU	NU	NU	NU	AC	TU	NU	AC	NU	AC	AC	TU
B	77	TU	NU	ND	NU	NU	NU	NU	ND	NU	ND	TU	ND	AC	FC	TU	NU
B	78	TU	NU	ND	FC	NU	NU	NU	NU	NU	ND	TU	ND	NU	FC	NU	NU
B	79	NU	FC	NU	FC	NU	NU	NU	NU	FC	NU	ND	AC	NU	FC	AC	TU
B	80	AC	NU	NU	TU	NU	NU	NU	TU	NU	ND	NU	AC	NU	AC	TU	NU
B	81	FC	NU	AC	NU	TU	NU	FC	TU	NU	ND	ND	ND	NU	FC	AC	TU
B	82	AC	NU	AC	TU	NU	ND	NU	NU	NU	ND	ND	AC	NU	FC	NU	NU
B	83	NU	ND	NU	NU	TU	AC	NU	ND	ND	ND	ND	ND	NU	FC	NU	NU
B	84	TU	NU	ND	NU	NU	NU	NU	NU	NU	NU	ND	AC	NU	NU	NU	NU
B	85	TU	AC	AC	TU	TU	NU	NU	NU	FC	ND	ND	ND	NU	ND	TU	NU
B	86	ND	TU	NU	AC	ND	NU	NU	ND	FC	ND	ND	ND	TU	ND	NU	TU
B	87	NU	TU	NU	TU	TU	NU	NU	NU	AC	ND	ND	ND	NU	NU	AC	NU
B	88	NU	NU	NU	NU	NU	NU	NU	ND	TU	ND	ND	ND	NU	NU	NU	NU
B	89	TU	FC	AC	NU	NU	TU	NU	NU	AC	ND	ND	ND	AC	FC	AC	TU
B	90	NU	FC	TU	AC	TU	NU	NU	NU	TU	NU	ND	NU	NU	TU	TU	TU
B	91	NU	FC	NU	TU	NU	NU	FC	AC	NU	NU	NU	TU	NU	TU	TU	TU
B	92	AC	FC	NU	FC	TU	TU	NU	AC	NU	NU	ND	AC	TU	FC	TU	TU
A	93	FC	AC	FC	FC	NU	TU	TU	AC	NU	NU	NU	AC	FC	FC	TU	TU

A	94	NU	TU	TU	FC	NU	[illegible]	[illegible]	[illegible]	TU	NU	ND	ND	NU	FC	NU	TU
A	95	AC	TU	TU	NU	TU	NU	AC	NU	TU	NU	NU	TU	NU	FC	TU	TU
A	96	AC	NU	TU	NU	TU	TU	NU	NU	FC	NU	ND	AC	NU	FC	NU	NU
A	97	NU	NU	AC	NU	NU	TU	NU	AC	NU	NU	NU	ND	AC	AC	NU	NU
A	98	NU	FC	NU	FC	AC	NU	NU	AC	FC	ND	NU	ND	AC	FC	AC	TU
A	99	TU	FC	NU	NU	NU	TU	NU	TU	FC	ND	NU	ND	NU	FC	NU	TU
A	100	AC	AC	TU	NU	NU	AC	TU	NU	FC	TU	NU	NU	TU	FC	TU	TU
A	101	FC	TU	TU	NU	AC	FC	NU	NU	NU	TU	NU	NU	FC	TU	NU	TU
A	102	TU	FC	NU	AC	NU	NU	TU	ND	NU	NU	NU	NU	NU	FC	NU	TU
A	103	NU	FC	AC	FC	NU	TU	NU	NU	NU	NU	NU	NU	NU	FC	TU	NU
A	104	NU	AC	AC	NU	AC	AC	AC	NU	FC	NU	NU	NU	NU	FC	AC	TU
A	105	NU	FC	AC	FC	NU	FC	AC	AC	ND	ND	NU	ND	NU	FC	TU	AC
A	106	FC	TU	ND	TU	ND	AC	AC	ND	NU	NU	ND	AC	NU	AC	NU	TU
A	107	NU	AC	TU	TU	NU	AC	NU	TU	NU	TU	NU	ND	FC	AC	AC	TU
A	108	AC	FC	AC	TU	NU	AC	AC	NU	NU	TU	NU	NU	NU	FC	NU	TU
A	109	TU	TU	FC	FC	NU	NU	AC	AC	NU	NU	NU	ND	TU	AC	AC	NU
A	110	NU	FC	AC	AC	TU	TU	AC	NU	NU	ND	ND	ND	NU	FC	NU	NU
A	111	NU	FC	NU	NU	NU	NU	ND	ND	ND	ND	ND	ND	NU	FC	TU	ND
A	112	FC	FC	FC	FC	AC	TU	AC	AC	FC	FC	NU	NU	FC	FC	AC	AC
A	113	FC	NU	AC	AC	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU
A	114	TU	AC	NU	FC	AC	TU	FC	AC	NU	FC	NU	NU	TU	FC	AC	NU
A	115	TU	AC	NU	FC	TU	NU	NU	NU	TU	ND	NU	NU	NU	TU	NU	NU
A	116	AC	NU	NU	TU	TU	NU	FC	TU	NU	NU	TU	NU	NU	AC	NU	NU
A	117	NU	AC	NU	TU	NU	NU	NU	TU	NU	NU	NU	ND	NU	NU	NU	NU
A	118	NU	FC	AC	FC	NU	AC	ND	ND	ND	ND	ND	ND	NU	FC	NU	NU
A	119	NU	ND	ND	TU	NU	ND	NU	TU	FC	NU	NU	ND	NU	AC	TU	NU
A	120	TU	NU	TU	NU	NU	TU	FC	NU	NU	TU	TU	ND	NU	AC	NU	NU
A	121	AC	FC	TU	TU	TU	TU	NU	AC	NU	NU	NU	NU	NU	NU	NU	TU
A	122	AC	NU	NU	FC	TU	AC	FC	TU	TU	NU	NU	TU	TU	FC	NU	TU
		Q1A	**Q1B**	**Q2B**	**Q3B**	**Q4A**	**Q4B**	**Q5B**	**Q6A**	**Q7A**	**Q7B**	**Q8B**	**Q9A**	**Q10A**	**Q10B**	**Q10C**	**Q1**

APPENDIX 5B: AVERAGE SCORES PER ELEMENT FROM THE QUESTIONNAIRE 2ND RUN

Test 1& 2	Correlating the 4 elements for Questionnaire 2nd run.			October 2007	
College	Students	ELM 1	ELM 4	ELM 7	ELM 10
B	1	2.5	0.5	1.0	1.3
B	2	2.0	0.5	0.5	1.7
B	3	1.0	0.5	1.0	2.0
B	4	1.5	0.0	2.0	0.7
B	5	1.5	0.5	4.0	2.0
B	6	2.5	1.0	2.0	1.3
B	7	1.5	1.5	0.5	1.7
B	8	1.5	0.5	3.0	2.3
B	9	2.5	1.0	1.0	3.7
B	10	3.0	1.0	2.5	2.3
B	11	2.5	1.0	1.5	2.3
B	12	2.5	0.0	1.0	1.3
B	13	2.5	0.5	0.0	0.7
B	14	2.5	1.5	2.5	1.7
B	15	3.0	0.5	1.5	2.3
B	16	2.5	2.0	2.0	2.0
B	17	2.5	1.5	2.5	2.3
B	18	0.5	0.0	1.5	2.0
B	19	3.0	0.0	0.0	1.7
B	20	2.0	0.5	1.0	0.7
B	21	1.0	0.5	1.5	0.7
B	22	2.5	1.0	1.0	2.3
B	23	1.5	1.0	2.5	2.7
B	24	2.5	1.5	2.5	1.7
B	25	2.5	2.0	2.0	3.0
B	26	3.0	2.5	2.5	3.0
B	27	1.5	1.0	2.0	1.7
B	28	1.5	1.0	1.0	2.7
B	29	3.0	0.0	0.5	1.7
B	30	2.5	1.0	1.0	2.7
B	31	3.0	0.5	0.5	2.0
B	32	1.0	1.0	1.0	1.7
B	33	2.0	1.0	1.0	2.0
B	34	2.5	1.0	1.5	1.7
B	35	2.5	0.5	1.5	2.0
B	36	2.0	1.5	1.5	1.0
B	37	3.0	0.5	1.5	1.7
B	38	2.0	1.5	1.5	2.0
B	39	2.5	1.0	1.5	2.0
B	40	1.0	0.5	1.0	1.7
B	41	1.5	1.0	1.5	2.3
B	42	3.0	0.5	2.0	1.3
B	43	2.5	0.5	1.5	1.3
B	44	3.0	1.5	2.5	2.7
B	45	2.0	1.5	0.0	2.3
B	46	3.5	0.5	0.0	0.7
B	47	1.5	0.5	0.5	2.0
B	48	2.5	1.5	2.0	1.7
B	49	3.0	1.0	1.5	2.0
B	50	2.0	0.5	2.0	1.7
B	51	2.5	1.0	3.0	2.0
B	52	1.5	0.5	2.5	0.3
B	53	1.5	1.0	2.5	1.7
B	54	2.5	1.5	2.5	1.3
B	55	2.5	1.0	2.5	2.7
B	56	3.0	2.5	1.5	2.3
B	57	2.0	0.5	1.0	1.7
B	58	2.5	0.5	1.5	2.7
B	59	2.5	2.0	1.0	1.3
B	60	3.0	1.0	2.5	1.3

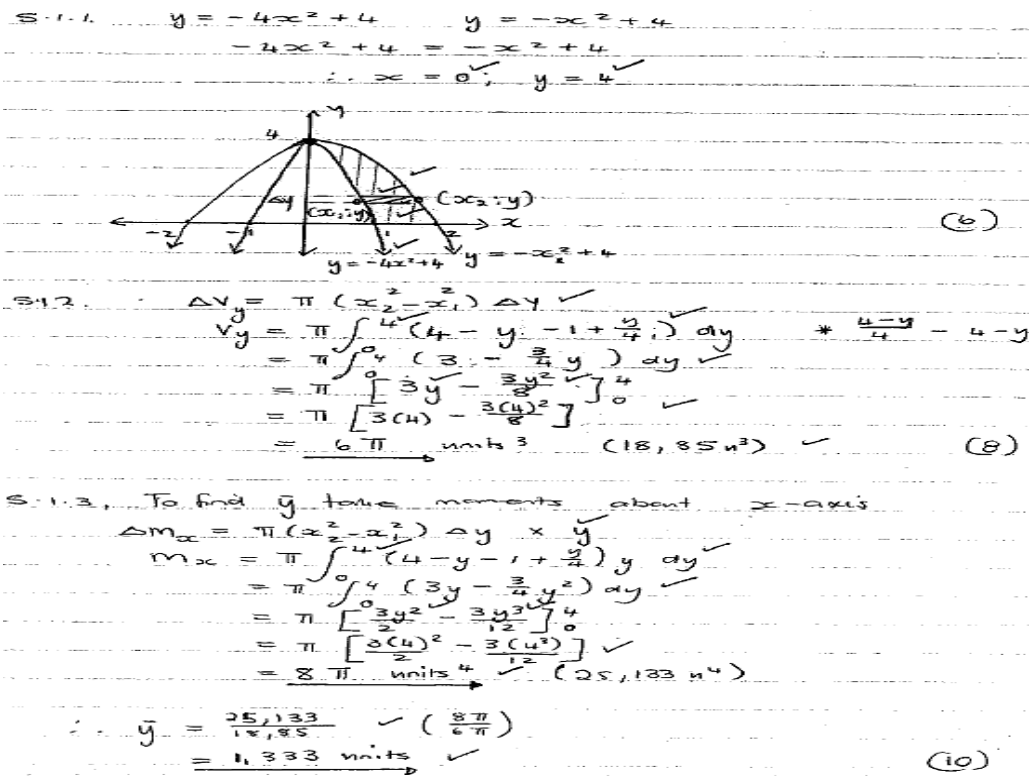
B	61	[illegible]	[illegible]	2.0	2.3
B	62	2.5	1.0	1.5	2.0
B	63	2.5	1.0	1.5	1.7
B	64	2.0	2.0	0.0	2.0
B	65	1.5	0.0	0.5	1.7
B	66	1.5	1.0	1.0	2.0
B	67	2.5	0.5	0.5	2.0
B	68	0.5	0.0	0.0	2.0
B	69	1.5	0.5	0.0	1.7
B	70	1.5	2.0	1.0	1.7
B	71	1.5	1.0	0.5	2.0
B	72	2.0	1.0	2.0	1.3
B	73	2.5	1.0	2.0	1.0
B	74	2.5	0.5	3.5	2.7
B	75	1.5	1.0	1.0	2.0
B	76	1.5	1.0	2.5	2.3
B	77	1.5	1.0	0.5	3.0
B	78	1.5	1.0	0.5	2.0
B	79	2.5	1.0	2.5	2.7
B	80	2.0	1.0	0.5	2.0
B	81	2.5	1.5	0.5	2.7
B	82	2.0	0.5	0.5	2.0
B	83	0.5	2.5	0.0	2.0
B	84	1.5	1.0	1.0	1.0
B	85	2.5	1.5	2.0	1.0
B	86	1.0	0.5	2.0	1.0
B	87	1.5	1.5	1.5	1.7
B	88	1.0	1.0	1.0	1.0
B	89	3.0	1.5	1.5	3.3
B	90	2.5	1.5	1.5	1.7
B	91	2.5	1.0	1.0	1.7
B	92	3.5	2.0	1.0	2.7
A	93	3.5	1.5	1.0	3.3
A	94	1.5	1.0	1.5	2.0
A	95	2.5	1.5	1.5	2.3
A	96	2.0	2.0	2.5	2.0
A	97	1.0	1.5	1.0	2.3
A	98	2.5	2.0	2.0	3.3
A	99	3.0	1.5	2.0	2.0
A	100	3.0	2.0	3.0	2.7
A	101	3.0	3.5	1.5	2.3
A	102	3.0	1.0	1.0	2.0
A	103	2.5	1.5	1.0	2.3
A	104	2.0	3.0	2.5	2.7
A	105	2.5	2.5	0.0	2.3
A	106	3.0	1.5	1.0	1.7
A	107	2.0	2.0	1.5	3.3
A	108	3.5	2.0	1.5	2.0
A	109	2.0	1.0	1.0	2.7
A	110	2.5	2.0	0.5	2.0
A	111	2.5	1.0	0.0	2.3
A	112	4.0	2.5	4.0	3.7
A	113	2.5	1.0	1.0	1.0
A	114	2.5	2.5	2.5	3.0
A	115	2.5	1.5	1.0	1.3
A	116	2.0	1.5	1.0	1.7
A	117	2.0	1.0	1.0	1.0
A	118	2.5	2.0	0.0	2.0
A	119	0.5	0.5	2.5	2.0
A	120	1.5	1.5	1.5	1.7
A	121	3.5	2.0	1.0	1.0
A	122	2.0	2.5	1.5	2.3
		ELM 1	**ELM 4**	**ELM 7**	**ELM 10**

APPENDIX 5C: MAIN RESULTS FOR THE QUESTIONNARE 2nd RUN (Test 3)

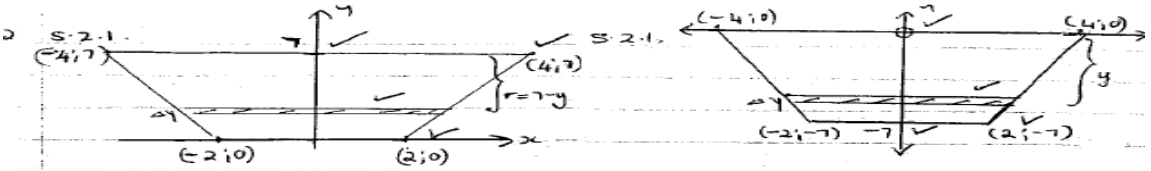
College	Students	Q9B	Q11B	Q3A	Q6B	Q8A	Q2A	Q5A
		DC-CD(A)	CGLCD	VA2D	2D-3D	CD(V)	AV2D	VA2D
B	1	TU	NU	FC	TU	TU	AC	FC
B	2	TU	NU	FC	NU	TU	TU	FC
B	3	TU	NU	AC	TU	TU	TU	FC
B	4	TU	NU	FC	NU	TU	TU	TU
B	5	TU	NU	FC	NU	TU	AC	FC
B	6	TU	NU	FC	TU	FC	AC	TU
B	7	TU	NU	AC	AC	NU	ND	AC
B	8	TU	NU	FC	ND	AC	TU	NU
B	9	NU	NU	FC	TU	TU	AC	TU
B	10	ND	NU	AC	TU	TU	NU	AC
B	11	TU	NU	FC	FC	TU	AC	FC
B	12	TU	TU	FC	FC	TU	AC	FC
B	13	TU	TU	NU	AC	NU	NU	FC
B	14	TU	NU	FC	FC	TU	TU	FC
B	15	TU	ND	AC	NU	TU	TU	TU
B	16	TU	NU	FC	FC	TU	AC	FC
B	17	TU	NU	FC	AC	TU	TU	FC
B	18	TU	ND	FC	TU	TU	AC	FC
B	19	TU	ND	FC	TU	TU	AC	TU
B	20	TU	NU	AC	FC	NU	AC	AC
B	21	TU	NU	AC	AC	NU	NU	TU
B	22	TU	ND	FC	AC	TU	TU	FC
B	23	TU	ND	NU	NU	NU	AC	TU
B	24	TU	NU	AC	TU	TU	TU	NU
B	25	TU	NU	FC	NU	TU	AC	NU
B	26	TU	NU	AC	FC	NU	ND	FC
B	27	TU	NU	NU	FC	TU	TU	FC
B	28	TU	NU	AC	TU	TU	AC	FC
B	29	TU	NU	FC	AC	TU	TU	FC
B	30	NU	NU	AC	NU	NU	TU	NU
B	31	TU	NU	NU	NU	NU	TU	FC
B	32	TU	NU	FC	TU	TU	AC	FC
B	33	TU	NU	FC	NU	TU	TU	FC
B	34	TU	ND	AC	NU	NU	AC	FC
B	35	ND	ND	AC	AC	TU	TU	NU
B	36	TU	ND	FC	NU	FC	AC	FC
B	37	ND	ND	ND	TU	TU	AC	FC
B	38	TU	NU	AC	TU	TU	NU	NU
B	39	ND	ND	ND	TU	TU	AC	FC
A	40	TU	NU	AC	NU	TU	AC	
A	41	NU	NU	FC	NU	TU	AC	NU
A	42	NU	NU	FC	NU	TU	NU	FC
A	43	TU	NU	AC	NU	TU	AC	FC
A	44	TU	ND	FC	TU	NU	AC	FC
A	45	TU	NU	FC	TU	FC	AC	NU
A	46	TU	NU	FC	NU	TU	TU	FC
A	47	TU	ND	AC	TU	FC	AC	TU
A	48	NU	NU	FC	NU	TU	AC	TU
A	49	TU	NU	FC	TU	TU	AC	FC
A	50	TU	NU	AC	FC	AC	AC	AC
A	51	NU	NU	FC	FC	TU	AC	FC
A	52	TU	ND	FC	TU	TU	AC	FC
A	53	TU	NU	FC	NU	TU	TU	NU
A	54	TU	NU	NU	AC	TU	TU	FC
		Q9B	Q11B	Q3A	Q6B	Q8A	Q2A	Q5A

APPENDIX 6A: DETAILED MEMORANDUM OF THE EXAMINATION QUESTIONS

Solution 1



Solution 2



S·2·1.
(y − 7)/(x − 4) = (0 − 7)/(2 − 4)
y = 7/2 x − 7
x = 2/7 (y + 7) (6)
dA = 2 [2/7 (y + 7)] dy
dA = 4/7 (y + 7) dy / (4/7 y + 4) dy
or dA = (0,571y + 4) dy

S·2·1.
(y − 0)/(x − 4) = (−7 − 0)/(2 − 4)
y = 7/2 x ∓ 14
x = 2/7 (y ∓ 14) x = 2/7 (y − 14)
dA = 2 [2/7 (y + 14)] dy (6)
dA = 4/7 (y + 14) dy / (4/7 y + 8) dy

S·2·2. ∫₀⁷ (7 − y) · 4/7 (y + 7) dy
= 4/7 ∫₀⁷ (49 − y²) dy
= 4/7 [49y − y³/3]₀⁷
= 4/7 [49(7) − 7³/3]
= 130,667 units³ (8)

S·2·2. ∫₋₇⁰ y [4/7 (y + 14)] dy
= 4/7 ∫₋₇⁰ [y² + 14y] dy
= 4/7 [y³/3 + 14y²/2]₋₇⁰
= 4/7 [0 − ((−7)/3)³ + 7(−7)²]
= −130,667 u³ (8)

S·2·3 ∫₀⁷ (7 − y)² 4/7 (y + 7) dy
= 4/7 ∫₀⁷ (343 − 7y² − 49y + y³) dy
= 4/7 [343y − 7y³/3 − 49y²/2 + y⁴/4]₀⁷
= 4/7 [343(7) − 7(7)³/3 − 49(7)²/2 + 7⁴/4]
= 571,667 u⁴

ȳ = 571,667 / 130,667
= 4,375 units (10)

∫₋₇⁰ y² [4/7 (y + 14)] dy
= 4/7 ∫₋₇⁰ (y³ + 14y²) dy
= 4/7 [y⁴/4 + 14y³/3]₋₇⁰
= 4/7 [0 − ((−7)⁴/4 + 14(−7)³/3)]
= 571,667 u⁴

ȳ = 571,667 / −130,667
= −4,375 u (10)

Alternative Solution 2

5.2.2 $\int_0^7 (7-y)\left(\frac{4}{7}y+4\right)dy$

$= \int_0^7 \left(4y + 28 - \frac{4}{7}y^2 - 4y\right)dy$

$= \int_0^7 \left(28 - \frac{4}{7}y^2\right)dy$

$= \left[28y - \frac{4}{21}y^3\right]_0^7$

$= 28(7) - \frac{4}{21}(7)^3$

$= 130{,}667 \ u^3$ (8)

5.2.3 $\int_0^7 (7-y)^2\left(\frac{4}{7}y+4\right)dy$

$= \int_0^7 \left(28y + 196 - 8y^2 - 56y + \frac{4}{7}y^3 + 4y^2\right)dy$

$= \int_0^7 \left(-28y + 196 - 4y^2 + \frac{4}{7}y^3\right)dy$

$= \left[-\frac{28y^2}{2} + 196y - \frac{4}{3}y^3 + \frac{4}{28}y^4\right]_0^7$

$= \left[-14(7)^2 + 196(7) - \frac{4}{3}(7)^3 - \frac{4}{28}(7)^4\right]$

$= 571{,}667 \ u^4$

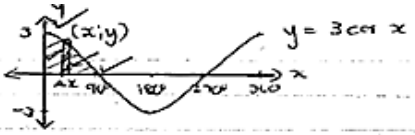
$\bar{y} = \frac{571{,}667}{130{,}667}$

$= 4{,}375 \ u$ (10)

Solution 3

5.3

5.3.1



$90° = \frac{\pi}{2}$ rad. (4)

5.3.2 $\Delta V = 2\pi x \times y \times \Delta x$

$= 2\pi \int_0^{90} x(3\cos x)\,dx$ $\quad f(x) = x \quad g'(x) = 3\cos x$

$= 2\pi \left[3x\sin x - \int 3\sin x\,dx\right]_0^{90} \quad f'(x) = 1 \quad g(x) = 3\sin x$

$= 2\pi \left[3x\sin x + 3\cos x\right]_0^{\pi/2}$

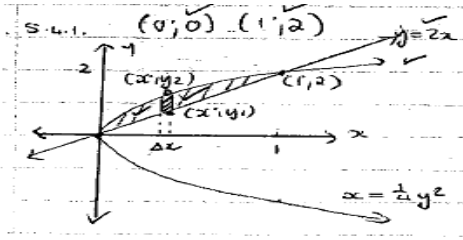
$= 2\pi \left\{\left[3\left(\frac{\pi}{2}\right)\sin\frac{\pi}{2} + 3\cos\frac{\pi}{2}\right] - \left[3\left(\frac{\pi}{2}\right)\sin 0 + 3\cos 0\right]\right\}$

$= 2\pi \left\{\left[\frac{3\pi}{2}\right] - [3]\right\}$

$= 10{,}759 \ u^3$ (10)

Solution 4

5.4 5.4.1



5.4.2 $\Delta A = (y_2 - y_1)\Delta x$

$A = \int_0^1 (\sqrt{4x} - 2x)\,dx$

$= \left[\frac{2x^{\frac{3}{2}}}{\frac{3}{2}} - \frac{2x^2}{2}\right]_0^1$

$= \frac{4}{3}(1)^{3/2} - (1)^2$

$= \frac{1}{3} \text{ units}^2$

5.4.3 $I_y = \int_0^1 (y_2 - y_1)x^2\,dx$

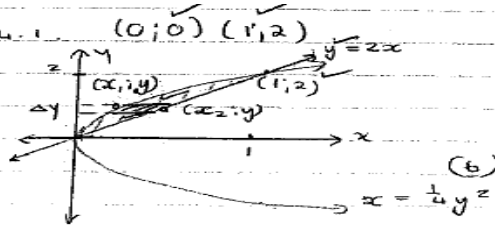
$= \int_0^1 (2\sqrt{x} - 2x)x^2\,dx$

$= \int_0^1 (2x^{5/2} - 2x^3)\,dx$

$= \left[\frac{2x^{7/2}}{7/2} - \frac{2x^4}{4}\right]_0^1$

$= 0{,}071 \ u^4$

5.4.1



(6)

5.4.2 $\Delta A = (x_2 - x_1)\Delta y$

$A = \int_0^2 \left(\frac{1}{2}y - \frac{1}{4}y^2\right)dy$

$= \left[\frac{1}{2}\cdot\frac{y^2}{2} - \frac{1}{4}\cdot\frac{y^3}{3}\right]_0^2$

$= \left[\frac{1}{4}(2)^2 - \frac{1}{12}(2)^3\right]$

$= \frac{1}{3} \text{ units}^2$ (6)

$I_y = \int_0^1 y x^2$

(6)

APPENDIX 6B: EXAMINATION ANALYSIS FOR 151 RESPONSES

	GMNP	GR	CD	VA3D	VA3D	GR	VA2D	VA2D	VA2D	GR	CD	VA3D	GMNP	GR	CD	VA2D	VA2D	MARKS	
	1.1	1.1	1.1	1.2	1.3	2.1	2.1	2.2	2.3	3.1	3.1	3.2	4.1	4.1	4.1	4.2	4.3	40	100
1	FC	FC	FC	NU	ND	FC	FC	AC	AC	FC	NU	FC	AC	FC	FC	AC	NU	25	64
2	NU	NU	NU	NU	ND	TU	NU	NU	ND	AC	FC	NU	ND	NU	NU	NU	ND	2	27
3	ND	NU	FC	TU	TU	TU	TU	AC	AC	AC	FC	AC	AC	FC	FC	FC	NU	20	44
4	NU	NU	TU	NU	NU	ND	NU	TU	TU	ND	ND	ND	ND	ND	ND	ND	ND	7	30
5	FC	AC	TU	FC	TU	TU	NU	ND	ND	AC	NU	TU	TU	TU	TU	TU	ND	11	50
6	ND	NU	ND	NU	ND	AC	TU	TU	TU	NU	NU	NU	AC	FC	ND	AC	NU	13	27
7	NU	ND	ND	ND	ND	TU	TU	AC	AC	ND	ND	ND	NU	ND	ND	TU	NU	8	30
8	FC	ND	ND	AC	ND	ND	ND	ND	ND	AC	ND	ND	AC	TU	ND	ND	ND	6	37
9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0	11
10	AC	AC	FC	FC	FC	FC	FC	FC	AC	AC	ND	TU	NU	NU	NU	TU	NU	24	62
11	FC	FC	ND	FC	NU	FC	FC	AC	AC	FC	NU	NU	FC	FC	FC	FC	NU	23	69
12	FC	ND	ND	NU	ND	ND	ND	ND	ND	FC	ND	ND	TU	TU	TU	ND	ND	4	8
13	NU	NU	FC	NU	NU	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1	32
14	FC	FC	AC	TU	NU	AC	AC	AC	AC	FC	NU	NU	AC	AC	FC	TU	AC	19	47
15	ND	ND	ND	ND	ND	AC	AC	AC	AC	AC	FC	AC	TU	AC	TU	FC	NU	18	42
16	TU	NU	TU	TU	NU	AC	AC	FC	FC	AC	NU	NU	TU	AC	TU	FC	NU	23	50
17	NU	NU	FC	NU	NU	ND	NU	NU	NU	NU	NU	TU	AC	NU	TU	AC	NU	8	34
18	NU	FC	ND	NU	ND	FC	FC	AC	AC	ND	ND	ND	ND	ND	ND	ND	ND	10	58
19	FC	FC	ND	NU	NU	NU	NU	ND	ND	AC	FC	AC	AC	NU	NU	NU	NU	4	40
20	FC	FC	AC	TU	NU	TU	ND	NU	NU	FC	NU	TU	TU	TU	TU	FC	NU	14	38
21	FC	FC	NU	NU	NU	ND	ND	ND	ND	FC	TU	TU	ND	FC	TU	AC	ND	11	45
22	ND	ND	ND	TU	ND	TU	TU	AC	AC	ND	ND	ND	ND	ND	ND	ND	ND	8	43
23	NU	NU	NU	NU	NU	NU	NU	ND	ND	TU	TU	ND	NU	NU	NU	NU	NU	4	29
24	ND	FC	NU	NU	ND	TU	NU	NU	ND	ND	ND	ND	ND	ND	ND	ND	ND	4	23
25	FC	NU	NU	NU	ND	ND	ND	ND	ND	TU	NU	ND	NU	NU	NU	ND	ND	3	26
26	FC	FC	FC	FC	FC	FC	FC	FC	AC	FC	NU	FC	FC	FC	FC	FC	NU	36	76
27	FC	NU	NU	NU	ND	TU	TU	TU	TU	ND	ND	ND	ND	ND	ND	ND	ND	5	31
28	TU	FC	FC	NU	NU	TU	TU	TU	TU	FC	NU	NU	NU	AC	TU	TU	ND	16	53
29	FC	FC	FC	NU	NU	FC	FC	AC	AC	AC	AC	NU	FC	AC	AC	FC	AC	26	61
30	FC	FC	NU	NU	ND	TU	TU	TU	TU	FC	FC	AC	FC	FC	FC	FC	AC	21	56
31	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0	33
32	FC	FC	FC	FC	AC	TU	TU	TU	TU	FC	FC	FC	TU	TU	TU	TU	NU	25	59
33	FC	FC	FC	NU	NU	ND	ND	ND	ND	ND	ND	ND	AC	TU	TU	TU	TU	24	49
34	TU	ND	ND	ND	ND	TU	TU	TU	TU	FC	NU	TU	FC	TU	TU	FC	NU	17	35
35	FC	AC	TU	NU	NU	TU	TU	TU	TU	AC	FC	TU	TU	NU	TU	NU	NU	12	34
36	FC	FC	FC	NU	TU	FC	FC	TU	TU	NU	NU	AC	FC	FC	FC	ND	ND	25	51
37	FC	FC	AC	NU	NU	FC	FC	FC	AC	NU	NU	TU	FC	FC	FC	FC	AC	25	59
38	FC	AC	FC	NU	NU	NU	NU	ND	ND	NU	NU	NU	NU	ND	ND	ND	ND	5	38
39	FC	AC	AC	AC	ND	TU	TU	TU	TU	FC	NU	TU	NU	NU	NU	ND	ND	17	43
40	FC	AC	AC	AC	ND	NU	NU	ND	ND	FC	NU	NU	AC	NU	NU	NU	NU	11	42
41	FC	AC	AC	AC	AC	AC	TU	NU	NU	FC	FC	AC	TU	NU	NU	AC	NU	18	45
42	NU	ND	ND	NU	NU	TU	TU	TU	TU	FC	NU	FC	FC	ND	ND	FC	NU	19	56
43	FC	FC	AC	AC	AC	TU	TU	TU	TU	FC	NU	AC	FC	ND	ND	FC	NU	24	66
44	NU	FC	ND	ND	ND	ND	ND	ND	ND	FC	ND	TU	NU	ND	ND	ND	ND	5	27
45	ND	ND	ND	ND	ND	FC	FC	FC	FC	FC	NU	TU	FC	TU	FC	NU	ND	18	47
46	FC	FC	AC	AC	TU	TU	TU	TU	TU	FC	NU	FC	FC	FC	FC	AC	NU	27	54
47	ND	ND	ND	ND	ND	TU	TU	TU	TU	FC	FC	AC	FC	TU	ND	FC	NU	16	48
48	NU	FC	AC	AC	NU	TU	TU	TU	TU	FC	NU	AC	NU	NU	NU	TU	NU	22	56
49	FC	FC	NU	TU	TU	FC	FC	AC	AC	AC	TU	AC	FC	AC	TU	TU	TU	20	45
50	FC	TU	TU	TU	TU	FC	FC	FC	FC	FC	NU	AC	FC	AC	TU	AC	TU	28	68
51	FC	FC	AC	NU	NU	FC	FC	AC	AC	FC	NU	NU	TU	TU	FC	FC	NU	19	47
52	FC	FC	FC	AC	AC	TU	TU	TU	TU	FC	NU	AC	FC	FC	FC	FC	NU	24	63
53	NU	ND	ND	ND	NU	FC	FC	NU	NU	AC	FC	NU	ND	FC	FC	NU	NU	6	31
54	FC	AC	NU	NU	ND	TU	TU	ND	ND	NU	NU	TU	TU	TU	ND	NU	NU	9	37
55	ND	ND	ND	ND	ND	TU	TU	TU	TU	FC	FC	ND	FC	FC	FC	FC	NU	14	50
56	FC	FC	FC	FC	FC	TU	TU	TU	TU	FC	NU	FC	TU	FC	FC	AC	NU	28	78

57	FC	FC	**FC**	**FC**	FC	TU	**TU**	**TU**	TU	FC	**FC**	**FC**	NU	ND	**ND**	**TU**	NU	**27**	**48**
58	FC	AC	**AC**	**NU**	NU	FC	**FC**	**FC**	FC	FC	**NU**	**TU**	FC	NU	**NU**	**FC**	NU	**23**	**56**
59	FC	FC	**FC**	**FC**	FC	AC	**FC**	**AC**	AC	FC	**FC**	**FC**	FC	FC	**FC**	**AC**	FC	**36**	**77**
60	FC	FC	**FC**	**NU**	NU	TU	**TU**	**TU**	TU	FC	**NU**	**AC**	FC	FC	**FC**	**FC**	ND	**21**	**56**
61	ND	FC	**FC**	**AC**	NU	TU	**TU**	**TU**	TU	FC	**ND**	**FC**	AC	FC	**FC**	**FC**	NU	**25**	**62**
62	FC	FC	**FC**	**AC**	FC	FC	**FC**	**FC**	FC	FC	**NU**	**AC**	FC	FC	**FC**	**AC**	FC	**35**	**82**
63	NU	AC	**NU**	**NU**	NU	TU	**TU**	**TU**	TU	FC	**ND**	**TU**	ND	TU	**NU**	**ND**	ND	**9**	**30**
64	FC	FC	**AC**	**NU**	NU	TU	**TU**	**TU**	NU	FC	**NU**	**TU**	AC	AC	**AC**	**TU**	NU	**10**	**30**
65	NU	AC	**NU**	**NU**	NU	FC	**FC**	**TU**	TU	FC	**NU**	**NU**	AC	FC	**FC**	**AC**	NU	**18**	**52**
66	TU	NU	**ND**	**NU**	ND	FC	**AC**	**AC**	AC	FC	**FC**	**TU**	AC	FC	**FC**	**AC**	ND	**16**	**49**
67	TU	TU	**ND**	**ND**	ND	TU	**TU**	**TU**	TU	AC	**FC**	**AC**	TU	FC	**FC**	**AC**	NU	**15**	**47**
68	FC	FC	**FC**	**FC**	FC	FC	**FC**	**FC**	FC	FC	**NU**	**FC**	FC	FC	**FC**	**FC**	NU	**37**	**90**
69	TU	ND	**ND**	**NU**	NU	TU	**TU**	**NU**	NU	AC	**FC**	**ND**	ND	ND	**ND**	**ND**	ND	**4**	**14**
70	FC	AC	**ND**	**ND**	ND	ND	**ND**	**ND**	ND	ND	**ND**	**ND**	ND	ND	**ND**	**ND**	ND	**2**	**33**
71	FC	NU	**ND**	**NU**	NU	NU	**NU**	**NU**	NU	FC	**ND**	**AC**	TU	TU	**TU**	**NU**	NU	**12**	**41**
72	FC	FC	**AC**	**NU**	NU	NU	**ND**	**ND**	ND	NU	**ND**	**NU**	NU	FC	**NU**	**NU**	TU	**7**	**29**
73	AC	FC	**ND**	**NU**	NU	ND	**ND**	**ND**	ND	FC	**FC**	**TU**	ND	ND	**ND**	**ND**	ND	**7**	**41**
74	ND	NU	**TU**	**NU**	NU	FC	**FC**	**FC**	AC	FC	**FC**	**NU**	ND	ND	**ND**	**ND**	ND	**15**	**37**
75	TU	NU	**ND**	**NU**	ND	TU	**TU**	**TU**	TU	AC	**FC**	**TU**	AC	NU	**ND**	**TU**	NU	**11**	**23**
76	TU	NU	**NU**	**ND**	ND	TU	**ND**	**TU**	TU	ND	**ND**	**ND**	ND	ND	**ND**	**ND**	ND	**4**	**42**
77	TU	ND	**ND**	**NU**	ND	TU	**TU**	**NU**	NU	ND	**ND**	**AC**	AC	ND	**ND**	**AC**	NU	**7**	**27**
78	FC	NU	**NU**	**FC**	NU	TU	**TU**	**AC**	AC	FC	**NU**	**TU**	FC	FC	**FC**	**FC**	NU	**21**	**52**
79	TU	NU	**NU**	**NU**	NU	NU	**NU**	**NU**	NU	AC	**NU**	**NU**	ND	NU	**NU**	**TU**	ND	**8**	**17**
80	FC	FC	**NU**	**AC**	AC	TU	**TU**	**TU**	TU	AC	**NU**	**AC**	TU	FC	**NU**	**AC**	NU	**20**	**44**
81	TU	ND	**ND**	**ND**	ND	TU	**ND**	**NU**	ND	ND	**ND**	**ND**	ND	ND	**ND**	**ND**	ND	**1**	**21**
82	FC	FC	**TU**	**NU**	ND	FC	**NU**	**AC**	AC	ND	**ND**	**ND**	ND	ND	**ND**	**ND**	ND	**12**	**40**
83	ND	ND	**ND**	**ND**	ND	ND	**ND**	**ND**	ND	ND	**ND**	**ND**	ND	ND	**ND**	**ND**	ND	**0**	**43**
84	FC	FC	**NU**	**AC**	TU	TU	**TU**	**AC**	AC	FC	**ND**	**TU**	ND	ND	**ND**	**ND**	ND	**21**	**59**
85	TU	FC	**NU**	**NU**	NU	TU	**TU**	**TU**	TU	TU	**NU**	**TU**	NU	ND	**ND**	**TU**	ND	**12**	**36**
86	FC	FC	**NU**	**AC**	AC	TU	**TU**	**TU**	TU	FC	**NU**	**AC**	AC	FC	**FC**	**AC**	AC	**19**	**62**
87	FC	FC	**NU**	**AC**	AC	AC	**AC**	**AC**	AC	FC	**FC**	**AC**	FC	FC	**FC**	**FC**	ND	**29**	**64**
88	FC	FC	**ND**	**NU**	ND	AC	**AC**	**AC**	AC	FC	**NU**	**FC**	FC	NU	**FC**	**FC**	NU	**21**	**60**
89	AC	AC	**TU**	**NU**	NU	TU	**TU**	**NU**	NU	FC	**NU**	**TU**	TU	NU	**FC**	**AC**	NU	**11**	**52**
90	FC	FC	**NU**	**FC**	TU	FC	**AC**	**AC**	AC	AC	**NU**	**ND**	ND	ND	**ND**	**ND**	ND	**17**	**41**
91	FC	FC	**FC**	**TU**	TU	FC	**FC**	**NU**	NU	FC	**NU**	**TU**	ND	ND	**ND**	**ND**	ND	**16**	**48**
92	FC	NU	**FC**	**FC**	NU	NU	**NU**	**TU**	TU	FC	**NU**	**AC**	FC	FC	**FC**	**TU**	NU	**14**	**45**
93	FC	FC	**ND**	**NU**	ND	AC	**AC**	**TU**	TU	FC	**NU**	**AC**	FC	FC	**ND**	**AC**	NU	**17**	**48**
94	AC	NU	**TU**	**FC**	TU	TU	**TU**	**ND**	ND	FC	**NU**	**TU**	FC	NU	**FC**	**FC**	FC	**18**	**48**
95	FC	FC	**FC**	**NU**	ND	AC	**AC**	**AC**	AC	FC	**NU**	**FC**	TU	ND	**ND**	**ND**	ND	**20**	**58**
96	TU	AC	**TU**	**NU**	NU	FC	**AC**	**AC**	AC	FC	**NU**	**AC**	TU	FC	**FC**	**AC**	NU	**17**	**50**
97	FC	AC	**TU**	**FC**	AC	TU	**TU**	**TU**	AC	FC	**NU**	**AC**	TU	FC	**FC**	**AC**	NU	**22**	**62**
98	FC	FC	**FC**	**NU**	NU	AC	**TU**	**AC**	AC	AC	**NU**	**AC**	FC	FC	**FC**	**FC**	NU	**21**	**65**
99	TU	ND	**ND**	**NU**	ND	AC	**TU**	**AC**	AC	FC	**NU**	**NU**	TU	FC	**ND**	**NU**	ND	**11**	**42**
100	AC	FC	**FC**	**TU**	ND	TU	**TU**	**TU**	TU	AC	**AC**	**TU**	ND	ND	**ND**	**ND**	ND	**10**	**17**
101	FC	FC	**AC**	**AC**	NU	TU	**TU**	**TU**	TU	ND	**ND**	**ND**	ND	ND	**ND**	**ND**	ND	**9**	**42**
102	AC	FC	**AC**	**NU**	NU	FC	**FC**	**FC**	AC	FC	**NU**	**FC**	AC	FC	**FC**	**FC**	NU	**26**	**61**
103	AC	AC	**FC**	**AC**	AC	FC	**FC**	**FC**	AC	FC	**NU**	**AC**	AC	AC	**FC**	**FC**	NU	**28**	**52**
104	FC	FC	**ND**	**NU**	NU	TU	**TU**	**TU**	TU	FC	**NU**	**TU**	AC	FC	**FC**	**FC**	NU	**18**	**54**
105	AC	FC	**NU**	**AC**	FC	TU	**TU**	**TU**	TU	FC	**NU**	**AC**	ND	FC	**FC**	**AC**	NU	**22**	**49**
106	NU	FC	**FC**	**NU**	NU	TU	**TU**	**TU**	TU	FC	**NU**	**FC**	TU	TU	**TU**	**NU**	NU	**15**	**53**
107	FC	NU	**TU**	**FC**	FC	TU	**TU**	**TU**	TU	AC	**ND**	**AC**	FC	FC	**FC**	**FC**	NU	**24**	**76**
108	FC	AC	**TU**	**NU**	TU	TU	**TU**	**TU**	TU	FC	**NU**	**FC**	AC	FC	**FC**	**AC**	NU	**17**	**59**
109	NU	NU	**ND**	**NU**	NU	FC	**FC**	**AC**	AC	FC	**NU**	**AC**	AC	TU	**TU**	**FC**	TU	**17**	**50**
110	ND	AC	**FC**	**ND**	ND	TU	**TU**	**ND**	ND	AC	**FC**	**NU**	ND	NU	**ND**	**ND**	ND	**5**	**23**
111	AC	AC	**NU**	**NU**	NU	TU	**TU**	**TU**	ND	FC	**FC**	**ND**	ND	ND	**ND**	**ND**	ND	**11**	**41**
112	TU	FC	**ND**	**TU**	TU	TU	**TU**	**TU**	TU	FC	**FC**	**AC**	AC	ND	**ND**	**FC**	NU	**22**	**60**
113	TU	AC	**TU**	**NU**	NU	FC	**FC**	**NU**	NU	FC	**NU**	**TU**	TU	NU	**ND**	**ND**	ND	**9**	**37**
114	AC	AC	**TU**	**ND**	ND	FC	**FC**	**TU**	ND	FC	**NU**	**NU**	AC	TU	**TU**	**AC**	AC	**15**	**49**
115	FC	FC	**FC**	**NU**	NU	FC	**FC**	**FC**	FC	FC	**NU**	**FC**	AC	AC	**FC**	**FC**	FC	**31**	**88**
116	TU	AC	**NU**	**NU**	ND	TU	**TU**	**TU**	TU	FC	**NU**	**AC**	ND	ND	**ND**	**ND**	ND	**11**	**51**

117	AC	FC	**NU**	**NU**	ND	FC	**FC**	**FC**	AC	FC	**FC**	**FC**	FC	FC	**FC**	**FC**	FC	**29**	**78**
118	ND	ND	**ND**	**ND**	ND	ND	**ND**	**ND**	ND	ND	**ND**	**ND**	ND	ND	**ND**	**ND**	ND	**0**	**20**
119	FC	FC	**ND**	**TU**	ND	ND	**ND**	**ND**	ND	FC	**ND**	**ND**	AC	NU	**ND**	**AC**	NU	**9**	**29**
120	ND	ND	**ND**	**ND**	ND	ND	**ND**	**ND**	ND	ND	**ND**	**ND**	ND	ND	**ND**	**ND**	ND	**0**	**25**
121	NU	ND	**ND**	**ND**	ND	ND	**ND**	**ND**	ND	AC	**ND**	**ND**	NU	NU	**NU**	**ND**	ND	**1**	**24**
122	FC	FC	**AC**	**FC**	ND	FC	**AC**	**AC**	NU	FC	**FC**	**AC**	NU	TU	**FC**	**FC**	NU	**21**	**32**
123	AC	AC	**NU**	**NU**	NU	TU	**TU**	**TU**	NU	TU	**NU**	**TU**	NU	NU	**TU**	**NU**	ND	**8**	**27**
124	NU	FC	**AC**	**NU**	ND	FC	**FC**	**FC**	FC	FC	**FC**	**AC**	FC	FC	**FC**	**FC**	NU	**27**	**69**
125	FC	TU	**ND**	**ND**	ND	TU	**TU**	**TU**	TU	FC	**NU**	**AC**	FC	FC	**FC**	**FC**	NU	**20**	**66**
126	NU	FC	**FC**	**AC**	AC	FC	**FC**	**AC**	AC	FC	**NU**	**AC**	AC	FC	**FC**	**FC**	NU	**23**	**45**
127	NU	NU	**NU**	**ND**	ND	TU	**TU**	**ND**	ND	ND	**ND**	**ND**	ND	ND	**ND**	**ND**	ND	**2**	**20**
128	NU	NU	**NU**	**TU**	NU	FC	**FC**	**AC**	AC	FC	**NU**	**AC**	AC	AC	**AC**	**TU**	NU	**17**	**56**
129	NU	NU	**NU**	**ND**	ND	TU	**TU**	**NU**	NU	AC	**NU**	**NU**	FC	TU	**FC**	**AC**	ND	**7**	**30**
130	TU	FC	**FC**	**NU**	NU	TU	**TU**	**TU**	TU	FC	**NU**	**NU**	AC	TU	**TU**	**TU**	NU	**10**	**24**
131	NU	NU	**NU**	**ND**	ND	AC	**NU**	**AC**	AC	FC	**NU**	**AC**	AC	TU	**TU**	**FC**	NU	**21**	**59**
132	AC	AC	**TU**	**FC**	FC	TU	**TU**	**TU**	TU	FC	**FC**	**FC**	AC	FC	**FC**	**FC**	NU	**31**	**73**
133	TU	ND	**ND**	**ND**	ND	TU	**TU**	**TU**	TU	FC	**FC**	**AC**	AC	ND	**ND**	**NU**	NU	**16**	**54**
134	FC	NU	**ND**	**ND**	ND	FC	**FC**	**FC**	AC	FC	**FC**	**AC**	FC	TU	**AC**	**FC**	ND	**21**	**49**
135	FC	FC	**FC**	**AC**	NU	AC	**NU**	**ND**	ND	ND	**ND**	**ND**	FC	FC	**ND**	**NU**	NU	**12**	**41**
136	NU	AC	**TU**	**TU**	ND	NU	**NU**	**ND**	ND	TU	**NU**	**NU**	AC	NU	**NU**	**AC**	ND	**7**	**28**
137	NU	TU	**TU**	**TU**	TU	FC	**AC**	**AC**	AC	AC	**NU**	**FC**	AC	NU	**NU**	**FC**	NU	**24**	**48**
138	TU	TU	**NU**	**NU**	NU	AC	**NU**	**TU**	TU	FC	**NU**	**NU**	TU	NU	**NU**	**FC**	NU	**13**	**29**
139	ND	ND	**ND**	**ND**	ND	FC	**FC**	**AC**	AC	FC	**NU**	**FC**	AC	FC	**FC**	**AC**	AC	**21**	**52**
140	NU	TU	**ND**	**NU**	ND	NU	**NU**	**NU**	NU	FC	**NU**	**NU**	NU	NU	**ND**	**NU**	NU	**8**	**16**
141	FC	NU	**TU**	**AC**	NU	TU	**TU**	**ND**	ND	FC	**NU**	**NU**	ND	ND	**ND**	**ND**	ND	**10**	**38**
142	NU	TU	**TU**	**NU**	NU	TU	**TU**	**TU**	TU	FC	**NU**	**TU**	AC	FC	**FC**	**AC**	AC	**19**	**64**
143	FC	FC	**NU**	**TU**	NU	TU	**TU**	**NU**	NU	NU	**FC**	**NU**	TU	FC	**NU**	**TU**	TU	**13**	**29**
144	NU	FC	**ND**	**TU**	NU	TU	**TU**	**TU**	TU	TU	**NU**	**NU**	AC	FC	**ND**	**FC**	NU	**15**	**40**
145	ND	ND	**ND**	**NU**	NU	TU	**TU**	**TU**	TU	FC	**FC**	**AC**	AC	AC	**FC**	**FC**	FC	**19**	**53**
146	TU	FC	**AC**	**TU**	ND	ND	**ND**	**TU**	TU	FC	**NU**	**NU**	FC	FC	**FC**	**TU**	ND	**19**	**55**
147	TU	NU	**AC**	**AC**	ND	ND	**ND**	**ND**	ND	FC	**NU**	**NU**	TU	TU	**TU**	**TU**	ND	**4**	**37**
148	NU	ND	**ND**	**ND**	ND	FC	**FC**	**AC**	FC	FC	**NU**	**NU**	FC	FC	**FC**	**FC**	NU	**20**	**50**
149	FC	TU	**NU**	**TU**	TU	NU	**TU**	**TU**	TU	FC	**NU**	**FC**	FC	TU	**TU**	**NU**	NU	**25**	**51**
150	FC	AC	**NU**	**NU**	NU	TU	**TU**	**TU**	TU	ND	**ND**	**ND**	ND	ND	**ND**	**ND**	ND	**11**	**37**
151	FC	NU	**TU**	**NU**	ND	NU	**NU**	**ND**	ND	NU	**NU**	**AC**	NU	NU	**NU**	**NU**	NU	**6**	**28**
AVRG																		**15.4**	**45.5**
	GMNP	**GR**	**CD**	**VA3D**	**VA3D**	**GR**	**VA2D**	**VA2D**	**VA2D**	**GR**	**CD**	**VA3D**	**GMNP**	**GR**	**CD**	**VA2D**	**VA2D**		
	1.1	1.1	1.1	1.2	1.3	2.1	2.1	2.2	2.3	3.1	3.1	3.2	4.1	4.1	4.1	4.2	4.3		
FC	70	63	32	17	10	38	33	16	9	89	31	21	38	50	52	45	6		
AC	13	26	19	21	10	15	12	31	38	25	2	41	37	12	4	28	8		
TU	22	8	21	18	14	66	65	56	51	6	3	29	24	23	23	20	6		
NU	28	29	33	67	57	12	19	17	17	9	81	29	17	27	20	18	74		
ND	18	25	46	28	60	20	22	31	36	22	34	31	35	39	52	40	57		
	151	**151**	**151**	**151**	**151**	**151**	**151**	**151**	**151**	**151**	**151**	**151**	**151**	**151**	**151**	**151**	**151**		
% FC+AC	54.9	58.9	33.8	25.2	13.2	35.1	29.8	31.1	31.1	**75.5**	21.9	41.1	49.7	41.1	37.1	48.3	9.3		

APPENDIX 6C: AVERAGE SCORES PER ELEMENT FROM THE QUESTIONNAIRE 2ND RUN

	GMNP	GMNP	GMNP av	GR	GR	GR	GR	GR av	CD	CD	CD	CDav	VA 3D	VA 3D	VA 2D	VA 2D	VA 2D	VA 3D	VA 2D	VA 2D	VA av	VA2D av	VA3D av
Students	**1.1**	**4.1**	**ELM 10**	**1.1**	**2.1**	**3.1**	**4.1**	**ELM 1**	**1.1**	**3.1**	**4.1**	**ELM 8**	**1.2**	**1.3**	**2.1**	**2.2**	**2.3**	**3.2**	**4.2**	**4.3**		**ELM 3**	**ELM 3**
1	4	3	3.5	4	4	4	4	4.0	**4**	1	4	3.0	**1**	0	**4**	**3**	3	**4**	**3**	1	2.4	2.8	1.7
2	1	0	0.5	1	2	3	1	1.8	**1**	4	1	2.0	**1**	0	**1**	**1**	0	**1**	**1**	0	0.6	0.6	0.7
3	0	3	1.5	1	2	3	4	2.5	**4**	4	4	4.0	**2**	2	**2**	**3**	3	**3**	**4**	1	2.5	2.6	2.3
4	1	0	0.5	1	0	0	0	0.3	**2**	0	0	0.7	**1**	1	**1**	**2**	2	**0**	**0**	0	0.9	1.0	0.7
5	4	2	3.0	3	2	3	2	2.5	**2**	1	2	1.7	**4**	2	**1**	**0**	0	**2**	**2**	0	1.4	0.6	2.7
6	0	3	1.5	1	3	1	4	2.3	**0**	1	0	0.3	**1**	0	**2**	**2**	2	**1**	**3**	1	1.5	2.0	0.7
7	1	1	1.0	0	2	0	0	0.5	**0**	0	0	0.0	**0**	0	**2**	**3**	3	**0**	**2**	1	1.4	2.2	0.0
8	4	3	3.5	0	0	3	2	1.3	**0**	0	0	0.0	**3**	0	**0**	**0**	0	**0**	**0**	0	0.4	0.0	1.0
9	0	0	0.0	0	0	0	0	0.0	**0**	0	0	0.0	**0**	0	**0**	**0**	0	**0**	**0**	0	0.0	0.0	0.0
10	3	1	2.0	3	4	3	1	2.8	**4**	0	1	1.7	**4**	4	**4**	**4**	3	**2**	**2**	1	3.0	2.8	3.3
11	4	4	4.0	4	4	4	4	4.0	**0**	1	4	1.7	**4**	1	**4**	**3**	3	**1**	**4**	1	2.6	3.0	2.0
12	4	2	3.0	0	0	4	2	1.5	**0**	0	2	0.7	**1**	0	**0**	**0**	0	**0**	**0**	0	0.1	0.0	0.3
13	1	0	0.5	1	0	0	0	0.3	**4**	0	0	1.3	**1**	1	**0**	**0**	0	**0**	**0**	0	0.3	0.0	0.7
14	4	3	3.5	4	3	4	3	3.5	**3**	1	4	2.7	**2**	1	**3**	**3**	3	**1**	**2**	3	2.3	2.8	1.3
15	0	2	1.0	0	3	3	3	2.3	**0**	4	2	2.0	**0**	0	**3**	**3**	3	**3**	**4**	1	2.1	2.8	1.0
16	2	2	2.0	1	3	3	3	2.5	**2**	1	2	1.7	**2**	1	**3**	**4**	4	**1**	**4**	1	2.5	3.2	1.3
17	1	3	2.0	1	0	1	1	0.8	**4**	1	2	2.3	**1**	1	**1**	**1**	1	**2**	**3**	1	1.4	1.4	1.3
18	1	0	0.5	4	4	0	0	2.0	**0**	0	0	0.0	**1**	0	**4**	**3**	3	**0**	**0**	0	1.4	2.0	0.3
19	4	3	3.5	4	1	3	1	2.3	**0**	4	1	1.7	**1**	1	**1**	**0**	0	**3**	**1**	1	1.0	0.6	1.7
20	4	2	3.0	4	2	4	2	3.0	**3**	1	2	2.0	**2**	1	**0**	**1**	1	**2**	**4**	1	1.5	1.4	1.7
21	4	0	2.0	4	0	4	4	3.0	**1**	2	2	1.7	**1**	1	**0**	**0**	0	**2**	**3**	0	0.9	0.6	1.3
22	0	0	0.0	0	2	0	0	0.5	**0**	0	0	0.0	**2**	0	**2**	**3**	3	**0**	**0**	0	1.3	1.6	0.7
23	1	1	1.0	1	1	2	1	1.3	**1**	2	1	1.3	**1**	1	**1**	**0**	0	**0**	**1**	1	0.6	0.6	0.7
24	0	0	0.0	4	2	0	0	1.5	**1**	0	0	0.3	**1**	0	**1**	**1**	0	**0**	**0**	0	0.4	0.4	0.3
25	4	1	2.5	1	0	2	1	1.0	**1**	1	1	1.0	**1**	0	**0**	**0**	0	**0**	**0**	0	0.1	0.0	0.3
26	4	4	4.0	4	4	4	4	4.0	**4**	1	4	3.0	**4**	4	**4**	**4**	3	**4**	**4**	1	3.5	3.2	4.0
27	4	0	2.0	1	2	0	0	0.8	**1**	0	0	0.3	**1**	0	**2**	**2**	2	**0**	**0**	0	0.9	1.2	0.3
28	2	1	1.5	4	2	4	3	3.3	**4**	1	2	2.3	**1**	1	**2**	**2**	2	**1**	**2**	0	1.4	1.6	1.0
29	4	4	4.0	4	4	3	3	3.5	**4**	3	3	3.3	**1**	1	**4**	**3**	3	**1**	**4**	3	2.5	3.4	1.0
30	4	4	4.0	4	2	4	4	3.5	**1**	4	4	3.0	**1**	0	**2**	**2**	2	**3**	**4**	3	2.1	2.6	1.3
31	0	0	0.0	0	0	0	0	0.0	**0**	0	0	0.0	**0**	0	**0**	**0**	0	**0**	**0**	0	0.0	0.0	0.0
32	4	2	3.0	4	2	4	2	3.0	**4**	4	2	3.3	**4**	3	**2**	**2**	2	**4**	**2**	1	2.5	1.8	3.7
33	4	3	3.5	4	0	0	2	1.5	**4**	0	2	2.0	**1**	1	**0**	**0**	0	**0**	**2**	2	0.8	0.8	0.7
34	2	4	3.0	0	2	4	2	2.0	**0**	1	2	1.0	**0**	0	**2**	**2**	2	**2**	**4**	1	1.6	2.2	0.7
35	4	2	3.0	3	2	3	1	2.3	**2**	4	2	2.7	**1**	1	**2**	**2**	2	**2**	**1**	1	1.5	1.6	1.3

36	4	4	4.0	4	4	1	4	3.3	4	1	4	3.0	1	2	4	2	2	3	0	0	1.8	1.6	2.0
37	4	4	4.0	4	4	1	4	3.3	3	1	4	2.7	1	1	4	4	3	2	4	3	2.8	3.6	1.3
38	4	1	2.5	3	1	1	0	1.3	4	1	0	1.7	1	1	1	0	0	1	0	0	0.5	0.2	1.0
39	4	1	2.5	3	2	4	1	2.5	3	1	1	1.7	3	0	2	2	2	2	0	0	1.4	1.2	1.7
40	4	3	3.5	3	1	4	1	2.3	3	1	1	1.7	3	0	1	0	0	1	1	1	0.9	0.6	1.3
41	4	2	3.0	3	3	4	1	2.8	3	4	1	2.7	3	3	2	1	1	3	3	1	2.1	1.6	3.0
42	1	4	2.5	0	2	4	0	1.5	0	1	0	0.3	1	1	2	2	2	4	4	1	2.1	2.2	2.0
43	4	4	4.0	4	2	4	0	2.5	3	1	0	1.3	3	3	2	2	2	3	4	1	2.5	2.2	3.0
44	1	1	1.0	4	0	4	0	2.0	0	0	0	0.0	0	0	0	0	0	2	0	0	0.3	0.0	0.7
45	0	4	2.0	0	4	4	2	2.5	0	1	4	1.7	0	0	4	4	4	2	1	0	1.9	2.6	0.7
46	4	4	4.0	4	2	4	4	3.5	3	1	4	2.7	3	2	2	2	2	4	3	1	2.4	2.0	3.0
47	0	4	2.0	0	2	4	2	2.0	0	4	0	1.3	0	0	2	2	2	3	4	1	1.8	2.2	1.0
48	1	1	1.0	4	2	4	1	2.8	3	1	1	1.7	3	1	2	2	2	3	2	1	2.0	1.8	2.3
49	4	4	4.0	4	4	3	3	3.5	1	2	2	1.7	2	2	4	3	3	3	2	2	2.6	2.8	2.3
50	4	4	4.0	2	4	4	3	3.3	2	1	2	1.7	2	2	4	4	4	3	3	2	3.0	3.4	2.3
51	4	2	3.0	4	4	4	2	3.5	3	1	4	2.7	1	1	4	3	3	1	4	1	2.3	3.0	1.0
52	4	4	4.0	4	2	4	4	3.5	4	1	4	3.0	3	3	2	2	2	3	4	1	2.5	2.2	3.0
53	1	0	0.5	0	4	3	4	2.8	0	4	4	2.7	0	1	4	1	1	1	1	1	1.3	1.6	0.7
54	4	2	3.0	3	2	1	2	2.0	1	1	0	0.7	1	0	2	0	0	2	1	1	0.9	0.8	1.0
55	0	4	2.0	0	2	4	4	2.5	0	4	4	2.7	0	0	2	2	2	0	4	1	1.4	2.2	0.0
56	4	2	3.0	4	2	4	4	3.5	4	1	4	3.0	4	4	2	2	2	4	3	1	2.8	2.0	4.0
57	4	1	2.5	4	2	4	0	2.5	4	4	0	2.7	4	4	2	2	2	4	2	1	2.6	1.8	4.0
58	4	4	4.0	3	4	4	1	3.0	3	1	1	1.7	1	1	4	4	4	2	4	1	2.6	3.4	1.3
59	4	4	4.0	4	3	4	4	3.8	4	4	4	4.0	4	4	4	3	3	4	3	4	3.6	3.4	4.0
60	4	4	4.0	4	2	4	4	3.5	4	1	4	3.0	1	1	2	2	2	3	4	0	1.9	2.0	1.7
61	0	3	1.5	4	2	4	4	3.5	4	0	4	2.7	3	1	2	2	2	4	4	1	2.4	2.2	2.7
62	4	4	4.0	4	4	4	4	4.0	4	1	4	3.0	3	4	4	4	4	3	3	4	3.6	3.8	3.3
63	1	0	0.5	3	2	4	2	2.8	1	0	1	0.7	1	1	2	2	2	2	0	0	1.3	1.2	1.3
64	4	3	3.5	4	2	4	3	3.3	3	1	3	2.3	1	1	2	2	1	2	2	1	1.5	1.6	1.3
65	1	3	2.0	3	4	4	4	3.8	1	1	4	2.0	1	1	4	2	2	1	3	1	1.9	2.4	1.0
66	2	3	2.5	1	4	4	4	3.3	0	4	4	2.7	1	0	3	3	3	2	3	0	1.9	2.4	1.0
67	2	2	2.0	2	2	3	4	2.8	0	4	4	2.7	0	0	2	2	2	3	3	1	1.6	2.0	1.0
68	4	4	4.0	4	4	4	4	4.0	4	1	4	3.0	4	4	4	4	4	4	4	1	3.6	3.4	4.0
69	2	0	1.0	0	2	3	0	1.3	0	4	0	1.3	1	1	2	1	1	0	0	0	0.8	0.8	0.7
70	4	0	2.0	3	0	0	0	0.8	0	0	0	0.0	0	0	0	0	0	0	0	0	0.0	0.0	0.0
71	4	2	3.0	1	1	4	2	2.0	0	0	2	0.7	1	1	1	1	1	3	1	1	1.3	1.0	1.7
72	4	1	2.5	4	1	1	4	2.5	3	0	1	1.3	1	1	0	0	0	1	1	2	0.8	0.6	1.0
73	3	0	1.5	4	0	4	0	2.0	0	4	0	1.3	1	1	0	0	0	2	0	0	0.5	0.0	1.3
74	0	0	0.0	1	4	4	0	2.3	2	4	0	2.0	1	1	4	4	3	1	0	0	1.8	2.2	1.0
75	2	3	2.5	1	2	3	1	1.8	0	4	0	1.3	1	0	2	2	2	2	2	1	1.5	1.8	1.0

76	2	0	1.0	1	2	0	0	0.5	1	0	0	0.3	0	0	0	2	2	0	0	0	0.5	0.8	0.0
77	2	3	2.5	0	2	0	0	0.5	0	0	0	0.0	1	0	2	1	1	3	3	1	1.5	1.6	1.3
78	4	4	4.0	1	2	4	4	2.8	1	1	4	2.0	4	1	2	3	3	2	4	1	2.5	2.6	2.3
79	2	0	1.0	1	1	3	1	1.5	1	1	1	1.0	1	1	1	1	1	1	2	0	1.0	1.0	1.0
80	4	2	3.0	4	2	3	4	3.3	1	1	1	1.0	3	3	2	2	2	3	3	1	2.4	2.0	3.0
81	2	0	1.0	0	2	0	0	0.5	0	0	0	0.0	0	0	0	1	0	0	0	0	0.1	0.2	0.0
82	4	0	2.0	4	4	0	0	2.0	2	0	0	0.7	1	0	1	3	3	0	0	0	1.0	1.4	0.3
83	0	0	0.0	0	0	0	0	0.0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.0	0.0	0.0
84	4	0	2.0	4	2	4	0	2.5	1	0	0	0.3	3	2	2	3	3	2	0	0	1.9	1.6	2.3
85	2	1	1.5	4	2	2	0	2.0	1	1	0	0.7	1	1	2	2	2	2	2	0	1.5	1.6	1.3
86	4	3	3.5	4	2	4	4	3.5	1	1	4	2.0	3	3	2	2	2	3	3	3	2.6	2.4	3.0
87	4	4	4.0	4	3	4	4	3.8	1	4	4	3.0	3	3	3	3	3	3	4	0	2.8	2.6	3.0
88	4	4	4.0	4	3	4	1	3.0	0	1	4	1.7	1	0	3	3	3	4	4	1	2.4	2.8	1.7
89	3	2	2.5	3	2	4	1	2.5	2	1	4	2.3	1	1	2	1	1	2	3	1	1.5	1.6	1.3
90	4	0	2.0	4	4	3	0	2.8	1	1	0	0.7	4	2	3	3	3	0	0	0	1.9	1.8	2.0
91	4	0	2.0	4	4	4	0	3.0	4	1	0	1.7	2	2	4	1	1	2	0	0	1.5	1.2	2.0
92	4	4	4.0	1	1	4	4	2.5	4	1	4	3.0	4	1	1	2	2	3	2	1	2.0	1.6	2.7
93	4	4	4.0	4	3	4	4	3.8	0	1	0	0.3	1	0	3	2	2	3	3	1	1.9	2.2	1.3
94	3	4	3.5	1	2	4	1	2.0	2	1	4	2.3	4	2	2	0	0	2	4	4	2.3	2.0	2.7
95	4	2	3.0	4	3	4	0	2.8	4	1	0	1.7	1	0	3	3	3	4	0	0	1.8	1.8	1.7
96	2	2	2.0	3	4	4	4	3.8	2	1	4	2.3	1	1	3	3	3	3	3	1	2.3	2.6	1.7
97	4	2	3.0	3	2	4	4	3.3	2	1	4	2.3	4	3	2	2	3	3	3	1	2.6	2.2	3.3
98	4	4	4.0	4	3	3	4	3.5	4	1	4	3.0	1	1	2	3	3	3	4	1	2.3	2.6	1.7
99	2	2	2.0	0	3	4	4	2.8	0	1	0	0.3	1	0	2	3	3	1	1	0	1.4	1.8	0.7
100	3	0	1.5	4	2	3	0	2.3	4	3	0	2.3	2	0	2	2	2	2	0	0	1.3	1.2	1.3
101	4	0	2.0	4	2	0	0	1.5	3	0	0	1.0	3	1	2	2	2	0	0	0	1.3	1.2	1.3
102	3	3	3.0	4	4	4	4	4.0	3	1	4	2.7	1	1	4	4	3	4	4	1	2.8	3.2	2.0
103	3	3	3.0	3	4	4	3	3.5	4	1	4	3.0	3	3	4	4	3	3	4	1	3.1	3.2	3.0
104	4	3	3.5	4	2	4	4	3.5	0	1	4	1.7	1	1	2	2	2	2	4	1	1.9	2.2	1.3
105	3	0	1.5	4	2	4	4	3.5	1	1	4	2.0	3	4	2	2	2	3	3	1	2.5	2.0	3.3
106	1	2	1.5	4	2	4	2	3.0	4	1	2	2.3	1	1	2	2	2	4	1	1	1.8	1.6	2.0
107	4	4	4.0	1	2	3	4	2.5	2	0	4	2.0	4	4	2	2	2	3	4	1	2.8	2.2	3.7
108	4	3	3.5	3	2	4	4	3.3	2	1	4	2.3	1	2	2	2	2	4	3	1	2.1	2.0	2.3
109	1	3	2.0	1	4	4	2	2.8	0	1	2	1.0	1	1	4	3	3	3	4	2	2.6	3.2	1.7
110	0	0	0.0	3	2	3	1	2.3	4	4	0	2.7	0	0	2	0	0	1	0	0	0.4	0.4	0.3
111	3	0	1.5	3	2	4	0	2.3	1	4	0	1.7	1	1	2	2	0	0	0	0	0.8	0.8	0.7
112	2	3	2.5	4	2	4	0	2.5	0	4	0	1.3	2	2	2	2	2	3	4	1	2.3	2.2	2.3
113	2	2	2.0	3	4	4	1	3.0	2	1	0	1.0	1	1	4	1	1	2	0	0	1.3	1.2	1.3
114	3	3	3.0	3	4	4	2	3.3	2	1	2	1.7	0	0	4	2	0	1	3	3	1.6	2.4	0.3
115	4	3	3.5	4	4	4	3	3.8	4	1	4	3.0	1	1	4	4	4	4	4	4	3.3	4.0	2.0

116	2	0	1.0	3	2	4	0	2.3	1	1	0	0.7	1	0	2	2	2	3	0	0	1.3	1.2	1.3
117	3	4	3.5	4	4	4	4	4.0	1	4	4	3.0	1	0	4	4	3	4	4	4	3.0	3.8	1.7
118	0	0	0.0	0	0	0	0	0.0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.0	0.0	0.0
119	4	3	3.5	4	0	4	1	2.3	0	0	0	0.0	2	0	0	0	0	0	3	1	0.8	0.8	0.7
120	0	0	0.0	0	0	0	0	0.0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.0	0.0	0.0
121	1	1	1.0	0	0	3	1	1.0	0	0	1	0.3	0	0	0	0	0	0	0	0	0.0	0.0	0.0
122	4	1	2.5	4	4	4	2	3.5	3	4	4	3.7	4	0	3	3	1	3	4	1	2.4	2.4	2.3
123	3	1	2.0	3	2	2	1	2.0	1	1	2	1.3	1	1	2	2	1	2	1	0	1.3	1.2	1.3
124	1	4	2.5	4	4	4	4	4.0	3	4	4	3.7	1	0	4	4	4	3	4	1	2.6	3.4	1.3
125	4	4	4.0	2	2	4	4	3.0	0	1	4	1.7	0	0	2	2	2	3	4	1	1.8	2.2	1.0
126	1	3	2.0	4	4	4	4	4.0	4	1	4	3.0	3	3	4	3	3	3	4	1	3.0	3.0	3.0
127	1	0	0.5	1	2	0	0	0.8	1	0	0	0.3	0	0	2	0	0	0	0	0	0.3	0.4	0.0
128	1	3	2.0	1	4	4	3	3.0	1	1	3	1.7	2	1	4	3	3	3	2	1	2.4	2.6	2.0
129	1	4	2.5	1	2	3	2	2.0	1	1	4	2.0	0	0	2	1	1	1	3	0	1.0	1.4	0.3
130	2	3	2.5	4	2	4	2	3.0	4	1	2	2.3	1	1	2	2	2	1	2	1	1.5	1.8	1.0
131	1	3	2.0	1	3	4	2	2.5	1	1	2	1.3	0	0	1	3	3	3	4	1	1.9	2.4	1.0
132	3	3	3.0	3	2	4	4	3.3	2	4	4	3.3	4	4	2	2	2	4	4	1	2.9	2.2	4.0
133	2	3	2.5	0	2	4	0	1.5	0	4	0	1.3	0	0	2	2	2	3	1	1	1.4	1.6	1.0
134	4	4	4.0	1	4	4	2	2.8	0	4	3	2.3	0	0	4	4	3	3	4	0	2.3	3.0	1.0
135	4	4	4.0	4	3	0	4	2.8	4	0	0	1.3	3	1	1	0	0	0	1	1	0.9	0.6	1.3
136	1	3	2.0	3	1	2	1	1.8	2	1	1	1.3	2	0	1	0	0	1	3	0	0.9	0.8	1.0
137	1	3	2.0	2	4	3	1	2.5	2	1	1	1.3	2	2	3	3	3	4	4	1	2.8	2.8	2.7
138	2	2	2.0	2	3	4	1	2.5	1	1	1	1.0	1	1	1	2	2	1	4	1	1.6	2.0	1.0
139	0	3	1.5	0	4	4	4	3.0	0	1	4	1.7	0	0	4	3	3	4	3	3	2.5	3.2	1.3
140	1	1	1.0	2	1	4	1	2.0	0	1	0	0.3	1	0	1	1	1	1	1	1	0.9	1.0	0.7
141	4	0	2.0	1	2	4	0	1.8	2	1	0	1.0	3	1	2	0	0	1	0	0	0.9	0.4	1.7
142	1	3	2.0	2	2	4	4	3.0	2	1	4	2.3	1	1	2	2	2	2	3	3	2.0	2.4	1.3
143	4	2	3.0	4	2	1	4	2.8	1	4	1	2.0	2	1	2	1	1	1	2	2	1.5	1.6	1.3
144	1	3	2.0	4	2	2	4	3.0	0	1	0	0.3	2	1	2	2	2	1	4	1	1.9	2.2	1.3
145	0	3	1.5	0	2	4	3	2.3	0	4	4	2.7	1	1	2	2	2	3	4	4	2.4	2.8	1.7
146	2	4	3.0	4	0	4	4	3.0	3	1	4	2.7	2	0	0	2	2	1	2	0	1.1	1.2	1.0
147	2	2	2.0	1	0	4	2	1.8	3	1	2	2.0	3	0	0	0	0	1	2	0	0.8	0.4	1.3
148	1	4	2.5	0	4	4	4	3.0	0	1	4	1.7	0	0	4	3	4	1	4	1	2.1	3.2	0.3
149	4	4	4.0	2	1	4	2	2.3	1	1	2	1.3	2	2	2	2	2	4	1	1	2.0	1.6	2.7
150	4	0	2.0	3	2	0	0	1.3	1	0	0	0.3	1	1	2	2	2	0	0	0	1.0	1.2	0.7
151	4	1	2.5	1	1	1	1	1.0	2	1	1	1.3	1	0	1	0	0	3	1	1	0.9	0.6	1.3
	GMNP	**GMNP**	**GMNP av**	**GR**	**GR**	**GR**	**GR**	**GR av**	**CD (V)**	**CD (V)**	**CD (V)**	**CDav**	**VA 3D**	**VA 3D**	**VA 2D**	**VA 2D**	**VA 2D**	**VA 3D**	**VA 2D**	**VA 2D**	**VA av**	**VA2D av**	**VA3D av**

APPENDIX 6D: RESPONSENSES FROM THE SEVEN STUDENTS

Elements	GMNP	GMNP	GR	GR	GR	GR	CD(V)	CD(V)	CD(V)	VA2D	VA2D	VA2D	VA2D	VA2D	VA3D	VA3D	VA3D
Question	1.1	4.1	1.1	2.1	3.1	4.1	1.1	3.1	4.1	2.1	2.2	2.3	4.2	4.3	1.2	1.3	**3.2**
S1	4	0	4	4	4	0	1	4	0	4	3	2	0	0	**3**	**3**	**2**
S2	4	4	4	4	4	0	1	4	0	4	4	4	0	0	**3**	2	**3**
S3	4	1	1	2	1	1	1	0	2	1	1	1	1	1	1	1	**0**
S4	4	2	4	4	4	0	1	0	2	4	4	4	0	0	**3**	1	**0**
S5	4	0	4	4	4	2	1	4	0	4	2	2	0	0	1	1	**2**
S6	4	0	4	4	0	4	1	0	4	4	4	4	2	1	**3**	1	**0**
S7	4	4	4	4	4	4	4	4	4	4	3	3	4	4	3	1	**3**

	GMNP	GR	CD(V)	VA2D	VA3D
FC	9	19	7	14	0
AC	0	0	0	3	8
TU	1	2	2	4	3
NU	1	3	6	6	7
ND	3	4	6	8	3
TOTAL	**14**	**28**	**21**	**35**	**21**
% (FC+ AC)	**64.3**	**67.9**	**33.3**	**48.6**	**38.1**

APPENDIX 7A: CONSENT FORM FOR STUDENTS

RESEARCH ON APPLICATION OF CALCULUS INVOLVING VISUALISATIONS: FROM AREAS TO VOLUMES

RESEARCH TO BE CONDUCTED BY: BLK MOFOLO

A PhD STUDY MARCH 2007

As a Mathematician and a Mathematics Instructor for the past **13 years**, I have been mostly worried about the way in which mathematics students in general battle with a section on **application of calculus including areas and volumes**. Most students in High schools, Technical Colleges (now referred to as College for FET) and Technikons (now referred to as Universities for Technology or Comprehensive Universities) are struggling with this section, they take time to learn what is required, some do not even manage to get it right. Most students nationally do not attempt questions under this section during the examination (if they attempt them they do not perform well). I decided to conduct a study, where I investigate how students learn this section with a particular focus on visualization, either dynamic (animations and graphics) with software or static with pictures.

I am doing research to promote the teaching and learning of calculus. **Students participating in this research do so voluntarily. Their names will not be revealed, only their written and verbal comments will be used.**

To be completed by students

Surname: ……

Course: ……...

Subject and level: …….

Signature: ……

Date:

I voluntarily participated to be part of this research. I am aware that the results from this research will be used to promote teaching and learning of calculus and for publications.

APPENDIX 7B: CONSENT FORM FOR CLASSROOM OBSERVATIONS

RESEARCH ON APPLICATION OF CALCULUS INVOLVING VISUALISATIONS: FROM AREAS TO VOLUMES

RESEARCH TO BE CONDUCTED BY: BLK MOFOLO: OCTOBER 2007

A PhD STUDY: University of PRETORIA

As a Mathematician and a Mathematics Instructor, I have been mostly worried about the way in which Mathematics students in general battle with a section on **application of Calculus on Areas and Volumes**. Most students in High schools, at the FET Colleges and at Universities battle with this section. Most students do not attempt examination questions under this section. My study is aimed at investigating some of these difficulties, where students' written and verbal interpretations will be recorded. A video recorder will be used to record all classroom interactions as teaching and learning takes place. Participation in this research is voluntary. All the recordings will be used for research only. The students' names, faces and their lecturer's name will not be revealed, only their interpretations as they solve problems will be used**.**

The results of this research will be shared by the Colleges and the Department of Education in order to promote teaching and learning in this section.

I …….(Surname and Initials)

Voluntarily participate in this research

Signature……...

Date…….....

Subject……...

Institution……..

APPENDIX 7C: CONSENT FORM FOR INSTITUTIONS

Pretoria 0002, South Africa
http:www.up.ac.za/academic/maths/
Department of Mathematics and Applied Mathematics
School for Mathematics
01 October 2007

This is to certify that Ms BLK Mofolo is registered at our university for the PhD degree in Mathematics Education under my supervision with prof AF Harding as co-supervisor.

She requests permission from the department to analyse students' scripts at the department for previous as well as forthcoming examinations. She would also like to have the statistics of the mathematics results for all 50 FET Colleges in South Africa which she will use in her research. The aim with her research is to investigate difficulties encountered by students as they solve problems on the section on solids of revolution which constitutes about 20%-40% of the final examinations.

Prof JC Engelbrecht

DEPARTMENT OF MATHEMATICS AND APPLIED MATHEMATICS

Ms Mofolo BLK

UNIVERSITY OF JOHANNESBURG

0825941271

APPENDIX 7D: CONSENT FORM FOR THE NATIONAL EXAMINATION

Pretoria 0002, South Africa
http:www.up.ac.za/academic/maths/
Department of Mathematics and Applied Mathematics
School for Mathematics
01 October 2007

This is to certify that ms BLK Mofolo is registered at our university for the PhD degree in Mathematics Education under my supervision with prof AF Harding as co supervisor.

She requests permission from your institution to administer a research instrument on volumes of solids of revolution. The aim of her research is to investigate difficulties encountered by students as they solve problems on the section on solids of revolution which constitutes about 20%-40% of the final examinations.

The research will involve students completing a questionnaire consisting of mathematics questions and interviews with students and lecturers.

Prof JC Engelbrecht

DEPARTMENT OF MATHEMATICS AND APPLIED MATHEMATICS