Reducing Math Anxiety, Improving Standards, and Maximizing Student Participation and Student Interaction

------A Practical Solution for the Classroom

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Abstract: Over the last ten and a half years I have created, developed, and refined three main strategies that form two closely related teaching methodologies. I refer to these strategies as **Special Techniques**, **Peer Responsibility**, and **Joint Projects**. The first two strategies combine together to form the first teaching methodology, **STAPRM**, and all three strategies combine together to form the second teaching methodology, **STAPRMJ**. **STAPRM** is an acronym for **S**pecial **T**echniques **a**nd **P**eer **R**esponsibility Teaching **M**ethod, while **STAPRMJ** is an acronym for **S**pecial **T**echniques **a**nd **P**eer **R**esponsibility Teaching **M**ethod with **J**oint Projects. The only difference between them is that in **STAPRM**, each student completes a total of six assignments, two questions from each of the three example tests they receive during the semester, while in **STAPRMJ**, students complete three *Joint Projects* ***instead*** of the assignments. I use **STAPRMJ** in my Statistics courses and **STAPRM** in all my other Mathematics courses.

Both **STAPRM** and **STAPRMJ** reduce anxiety and improve standards in any course in which they are used. They also maximize student participation and student interaction during the course, as well as student-instructor interaction. There are also other advantages that were unforeseen and unexpected during the development of these teaching methodologies. For example, because there is greater student-instructor interaction, it is possible to monitor the progress of each student far better than before, and it is impossible for a student to obtain a good grade in the course because they have good partners. Each student must complete his or her own work to succeed in the course.

This proposal discusses the 23 techniques that form the *Special Techniques*, some of which form the new style of teaching I developed to optimize my time in the classroom, the structure and organization of *Peer Responsibility*, and some examples of *Joint Projects*. All the examples and discussions within this proposal are related to Mathematics courses because this is my discipline. However, these teaching methodologies can also be used in many other disciplines.

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This is the introduction to the description of the new teaching methodology called *staprm* in the eric database. A paper that contains some new ideas, plus a full description of *staprmj*, a closely related methodology, together with the final version of staprm is currently being written. This paper will also describe everything that I would have liked to known when I first started teaching 35 years ago!

1. INTRODUCTION - (IN ERIC - FEBRUARY 2003)

I had been teaching for over *twenty-five years* both in **America** and **England**, when I was asked to teach a **College Algebra course** at the *100 level* during the ***spring term*** of ***1995***. Due to the differences in the educational systems between America and England, this was my first exposure to this introductory course. I was horrified at the apathy, apprehension, and lack of enthusiasm on the part of the students taking the course. Many students were attempting the course for the third or fourth time. Those repeating were quiet, almost lifeless. Some sat alone while others sat together in-groups and laughed at their own mathematical incompetence. More disturbing was their overall attitude towards the subject of Math. They had no confidence in their ability whatsoever with many of them anticipating failure before the course had even started. I was also astonished at some of the things the students did in tests and assignments. The following examples are just two of the many that I encountered while teaching this course.

EXAMPLE 1

On one of my tests, a student had ended up with the expression $\frac{x - y}{xy}$.

He proceeded to simplify this expression as follows :

$$\frac{x - y}{xy} = \frac{\cancel{x} - \cancel{y}}{\cancel{x}\cancel{y}} = -$$

This is literally a ***negative sign*** all by itself!

EXAMPLE 2

I was standing near a student watching her complete an exercise. She had ended up with the expression $\frac{\log(1+x^2)}{(1+x^2)}$. She proceeded to simplify this expression as follows :

$$\frac{\log(1+x^2)}{(1+x^2)} = \frac{\log \cancel{(1+x^2)}}{\cancel{(1+x^2)}} = \log$$

While I was surprised at what she had done, I could not help being amused at the error. So, as a joke, I said, "Surely that answer is much too big. The answer ought to be **Twig**". She looked up at me, and very reproachfully said, "You have not taught us the **Twig** function yet!"

These examples, together with many others, started me thinking about the underlying problems, that is, lack of mathematical ability and lack of confidence. Why do students carry out such totally wrong operations? How can I give them confidence in their mathematical ability and stop them treating the subject as one that they must inevitably fail? It is not unreasonable to expect this negative attitude to extend into any other subject that is mathematically orientated. So possibly finding a way to give students some confidence in their own ability in *College Algebra* may well help them substantially in other courses that involve mathematical concepts and operations.

After teaching the *spring 1995 College Algebra course*, it was clear that many students had created their own totally wrong set of rules. They had either remembered the rules of mathematics incorrectly or had never understood them in the first place. With this in mind, I created my *catchphrase* (on *Page 5*). On the first day of class, I use an overhead projector slide of *Page 5* and describe the cricketing exploits of *Bellarmine University's* first and only cricket team. The purpose is to emphasize the importance of learning the real rules of mathematics and reinforcing them by solving a large number of problems. Also, identifying the common problems among my students seems to decrease their Math anxiety. Later in my courses, when my students and I have become better acquainted, if I start to use the *catchphrase*, quite often some of my students will chant the rest of it back to me! Also they frequently write part of the catchphrase, such as "*Maths is fun*" on their assignments or tests (including the *s* on Math!). I now use my catchphrase in all my courses. It is also pinned on my office door.

From the spring of 1995 to the beginning of 1999, I created and tested a large number of different ideas that I refer to, collectively, as ***Special Techniques*** (I have never liked the word *techniques*, but I cannot think of a better one!). Some of the *techniques* were designed to reduce *Maths Anxiety*, some to give my students hope throughout the course, even after one or even two poor test marks, some to improve standards, and some were designed to optimize my time in the classroom. I also wanted to keep my students focused and interested during class and boost their mathematical confidence.

By the middle of 1999, I was using all of those *Special Techniques* that were judged successful, in my *M116, Pre-Calculus* courses, my *M301, Differential Equations* courses, as well as my *M105, College Algebra* courses and they were working very well. However, while my students did talk to me, and the atmosphere in the classroom was far more relaxed and happier than before, they did not interact with each other very much and I thought that they would benefit if they did.

At the beginning of the summer of 1999, I remembered how much I had learned about Maths, when I marked my students' assignments and tests during my first few years of teaching. It occurred to me that if each student marked the work of another student, they might well benefit in a similar way. I thought that this strategy would make my students responsible for the progress of the other students on the course, because each student needs one of their partners to complete the assigned work, so that they can mark it and obtain their *marking marks*. However, the *marking marks* are independent of a student's ability, since the *marker* only has to recognize whether a question is correct or incorrect. I believe that *peer pressure* is the strongest force in the classroom, and it would be very effective in this situation.

I now have my students working in threes (with some twos, when necessary). I call each group of students a ***partnership*** and each student in a *partnership* a **partner**. I select three sets of problems from the end of each section of the textbook that will be covered during the course. I call one set **Set A**, the second **Set B**, and the third **Set C**. The *partner* whose last name is nearest the beginning of the alphabet completes **Set A**. The next nearest the beginning of the alphabet completes **Set B**. The third, if there is one, completes **Set C**. If there are only two students in a partnership **Set C** is ignored. When a partner completes his or her own set of problems, they then mark the set of problems of ***ONE*** of their partners. They must then organize their work into ***one*** **joint workbook**. I call this strategy ***Peer Responsibility***. This strategy has had an amazing effect. There is nothing like *peer pressure* to get students working together! Note that in all of the courses I teach, 99% of the solutions and marking in the workbook is completed outside class time. While this is not necessary, I do it so that I have ample time to cover the concepts and complete related problems in class.

If all students in a partnership cannot do a question, I encourage them to talk to another partnership or come to me for assistance. Frequently, only one member of a partnership will come to me because the other partners are not free at the same time. In this case, I help this student and then he or she teaches the other partners. I have also arranged the marking scheme so that by talking to each other, students can stop their partners losing marks and help them obtain bonus marks. I felt that this approach would force students to interact, thereby maximizing student participation and student interaction. Many students have never marked the work of another student and even when they have they still have questions that need to be answered. When they have questions about marking the obvious person to ask is the instructor. This substantially increases student-instructor interaction.

During the summer of 1999, I developed strategies to deal with every possible situation that I thought could occur with *Peer Responsibility*. I then combined the *Special Techniques* and *Peer Responsibility* into one teaching methodology that I call **STAPRM**. **STAPRM** is an acronym for ***S****pecial* ***T****echniques* **a**nd ***P****eer* ***R****esponsibility (Teaching)* ***M****ethod*. I say **STAPRM** as two syllables, the **STA** like the *sta* in the word *sta*ck, followed by *prom* for **PRM**. I started testing **STAPRM** on my students during the *Fall 1999 semester* in both my **M105 – College Algebra** and **M116 – Pre-calculus courses**.

Needless to say, in spite of my efforts, there were many situations that I had not foreseen!!! So, I had my students evaluate what I called at that time "*The Experiment*". Many students, including

a number of older students, made some very useful comments, which allowed me to make improvements in time to use **STAPRM** in my *Spring 2000* **M301 – Differential Equations course**.

Completing the **workbook** gives my students the practice they need, which is absolutely essential in any Math course. This in turn improves the standard of their work and their understanding of the concepts. In view of this, the latest marking scheme makes completing the *workbook* essential. I have also found that this approach allows me to monitor each student's progress throughout the course very closely and far more easily than before. It has also bonded my students and I in a way that was unexpected and unforeseen before the term started. To get the best from this pedagogy, I developed a completely different style of teaching that maximizes the amount of time I have in the classroom to discuss the concepts and complete problems. It works best in a multimedia classroom, although if unavailable, I can, and very often have, managed without.

Peer Responsibility has had some unexpected bonuses. I had one student in my *College Algebra* class come up to me after a class and tell me that she had just finished marking her partner's work. She was very happy and excited about it. She ended with the comment "*Mary is as dumb as I am*!" At first sight, this does not sound too promising. However, when analyzed, what she is really saying is that she had realized for the first time that she is neither alone nor the worst student in the Math class. This made her feel better, which in turn reduced her anxiety about the course. Another bonus is the fact that since each partnership creates just one workbook, the students themselves monitor each other throughout the course, which reduces the possibility of cheating.

I created this teaching methodology to minimize the amount of time an instructor spends organizing the course, so that he or she has more time to spend teaching and interacting with the students. The following **Excel** files have been created to make keeping track of all the marks and grades as simple as possible

- MarksRegisterAssignmentsBLANK.xls
- YourGradeAssignments.xls

where the word BLANK is replaced with something that identifies a course uniquely. For example, for this I term I am using a file with filename **MarksRegisterAssignmentsF2005M117ER.xls** to record all the marks of my M117ER – Calculus 1 course. The file **MarksRegisterAssignmentsBLANK** would be used by the instructor to keep track of the marks and grades of each student throughout the course and the file **YourGradeAssignments** would be used by each student to keep track their own mark and grade throughout the course.

STAPRM is based on **5** methods of assessment ***during*** the semester, each worth **120 marks**, and a **Final** worth **400 marks**. These methods of assessment are listed below :

1) Assignments 120
2) Workbook Solutions 120
3) Workbook Marking 120
4) Test 1 120

5)	**Test 2**	**120**
6)	**Final**	**400**
TOTAL MARKS FOR COURSE		**1000**

If the instructor of any course from any discipline creates assessments using the same format, both **MarksRegisterAssignments#** and **YourGradeAssignments** can be used. It is very simple to change the labels within each file so that they fit the selected assessment format.

After using **STAPRM** with over 350 students, their evaluations and reactions make it clear that it is a popular and successful teaching methodology. Over the years, the age gap between my students and I has increased and it seemed as if this fact made my students less willing to come and see me. However, *Peer Responsibility* has had an amazing effect. It has caused my students and me to become united in a way I would never have thought possible. This has made the last few years some of the most exciting and fun-filled years I have had in over 30 years of teaching. In short, this pedagogy works! It reduces Math Anxiety, it gives students hope throughout the course and it maximizes student participation and student interaction with each other and with the instructor. At the same time, the practice in the workbook improves standards, and even better, it is ***fun*** for me and for my students!

There are also other advantages that were unforeseen and unexpected during the development of these teaching methodologies. For example, I can monitor the progress of each student far better than before, and it is impossible for a student to obtain a good grade in the course just because they have good partners because each student must complete his or her own work to succeed in the course. However, good partner(s) can, and very often have, helped a less able student succeed in a course who would otherwise have failed. I have also received comments at conferences from other instructors who are using **STAPRM** and each instructor has confirmed that **STAPRM** does achieve its goals.

Since 1995, I have developed an evaluation form that asks my students to rate the *Special Techniques* and *Peer Responsibility* both numerically and with comments, while encouraging them to make suggestions. This form is now very comprehensive. Over the years, the numerical data and the comments about these strategies produced some surprises for me. In view of this, I have abandoned some of the techniques, because they did not achieve their objective, and refined others. I also modified both *Peer Responsibility* based on the numerical data and the comments I received. I deliberately created **STAPRM** so that it can be used by any teacher, and in any Mathematics course. Recently, colleagues have informed me that **STAPRM** can also be used in History, Education, Psychology, and Computer Science courses and in many other disciplines as well, not just Mathematics.

Incidentally, for some years I handed out the evaluation forms towards the end the class and then left the room without returning. Recently I discovered, if I teach for about 15 minutes (to ensure the stragglers have arrived), then hand out my forms, making it clear that I intend to continue teaching after they have completed them, I get far more useful information.

The purpose of this proposal is to describe how to use this teaching methodology in the classroom. Chapter 2 describes how to introduce the *Special Techniques* into a course and the

organization and structure of *Peer Responsibility*. The 23 techniques that form the *Special Techniques* are discussed in detail in Chapter 3. This chapter also describes the new style of teaching I developed to optimize my time in the classroom. *Peer Responsibility* is discussed in Chapter 4. Chapters 3 and 4 have been written so that each chapter is, as far as possible, independent of one another, so there is some duplication between Chapters 2, 3, and 4. An analysis of these strategies, based on the evaluations completed by my students, is in *Chapter 5*. The cost of implementing this teaching methodology is discussed in *Chapter 6*, with a conclusion in *Chapter 7*. All the courses discussed within this proposal are Mathematics courses because I teach Mathematics courses. All essential files that an instructor would need to use this methodology are available via the Internet.

2. THE STRATEGIES AND THE TEACHING METHODOLOGIES

Over the last eleven years, I have developed three strategies that combine to form two closely related teaching methodologies. The three strategies are :

THE SPECIAL TECHNIQUES

The Special Techniques are a large number of ideas that are designed to solve a number of different problems. Some reduce *Maths Anxiety*, some give my students hope throughout the course, even after one or even two poor test marks, some improve standards, and some are designed to optimize my time in the classroom. They also keep my students focused and interested during class and boost their mathematical confidence. I have never liked the word *techniques*, but I cannot think of a better one! Currently there are 27 techniques. A summary of them, which includes the rank for each technique given to them by my students, starts on page 9.

PEER RESPONSIBILITY

Peer Responsibility can be summed up in just eight words, "*making students mark the work of other students*", although making it happen is a little more complicated! This strategy really does reduce Math Anxiety, improve standards, and maximize student participation and interaction both with other students and the instructor. It has completely removed the age barrier between my students and I (I am 64 years old). One of the most important reasons why it is such a successful strategy, is that students can see that it does make them teach each other, learn from each other, talk to each other, and help one another ***and they like it***. Students must like a strategy for a strategy to be successful and they like Peer Responsibility. A summary of Peer Responsibility starts on page 13.

JOINT PROJECTS

I use Joint Projects in my Statistics courses only. I include some of the projects I use and examples of them starting on page 23. Students complete and sign the *Division of Work form* (Page 27) and put it at the end of the copy of the project they want me to mark. I have tried and tested many ideas to determine who did the work and who did not and the *Division of Work form* does identify those students who are not doing their share of the work. It is the most certainly the most successful idea to date.

STAPRM

The **Special Techniques** when combined with **Peer Responsibility** form **STAPRM** which is an acronym for

Special **T**echniques **A**nd **P**eer **R**esponsibility (Teaching) **M**ethod

STAPRM can be used in : *All Mathematics Courses* ***EXCEPT*** *Statistics Courses And Many Courses in other Disciplines*

STAPRMJ

The **Special Techniques**, **Peer Responsibility**, and **Joint Projects** form **STAPRMJ** which is an acronym for

Special **T**echniques **A**nd **P**eer **R**esponsibility (Teaching) **M**ethod With **J**oint Projects

STAPRMJ can be used in : *Statistics Courses*
Other Disciplines that Permit Varied Creative Projects

OBJECTIVES

STAPRM and **STAPRMJ** are designed to reduce Math Anxiety, improve standards and maximize *student participation* and *student interaction* in all courses in which they are used. Even better is the fact that Peer Responsibility, in particular, is fun to use for both the students and the instructor. And as a bonus for me, I have far less marking to do now, than at any time in my 35 years of teaching.

3. A SUMMARY OF THE SPECIAL TECHNIQUES

The numbers at the end of each technique indicate the rank of the technique. These numbers were obtained from my evaluation forms completed at the end of a course by all students present. A complete and detailed discussion of each technique is part of the proposal that won the 2002 Metroversity Award for Instructional Development.

3.1 TECHNIQUES TO REDUCE MATH ANXIETY

1. Provide Complete Solutions to Some Typical Problems Written Using the Language of Mathematics Correctly - 15th
2. Provide an Example Test Before Each Real Test (Including the Final) - 1st
3. No Time Limit on Tests, Including the Final (as far as possible) - 3rd
4. Take One Sheet of Paper into a Test Including the Final - 2nd
5. All Questions on the Tests Straight from or Similar to Questions in the Textbook or on the Example Tests - Joint 4th
6. **Never** Require Students to Remember Formulae BUT Must Know When to Use a Formula and, If the Formula has been Forgotten, Must Know Where to Find It - 7th
7. Graded Bonuses on all Tests (to encourage students to think during the Test) - Joint 4th
8. YourGrade file (Excel workbook) – this file allows every student to keep track of their own mark and grade throughout the course

9. Providing Information in Exchange for Marks During a Test - Being Tested

Peer Responsibility has also had a substantial positive impact on the attitude of my students in all of my courses.

3.2 TECHNIQUES TO GIVE STUDENTS HOPE THROUGHOUT THE COURSE

10. Unlimited Bonuses Available for the Solutions in the Workbook - 6th
11. 90% or More in Final Rule for Eligible Students (Provided ***ALL*** Assignments/Projects and Workbook Complete) - 8th
12. Top 20% or 25% in Final Rule for Eligible Students (Provided ***ALL*** Assignments/Projects and Workbook Complete) - 9th

3.3 TECHNIQUES TO IMPROVE STANDARDS

13. ***Peer Responsibility*** - Completing Sets of Questions from the textbook (10th) and Marking The Questions of ONE Partner in the Workbook (20th).
14. Any Numerical Answer Requires a Sentence Containing the Number in the Context of the Question - ***Absolutely Last As Always***!
15. Showing Students Errors Made by Students in Previous Courses - 14th
16. Bonus Marks for Attendance During the Last Four Weeks of the Course - ***Still Being Tested.***
17. Completing homework problems with one selected at random as a bonus - ***Being Tested.***

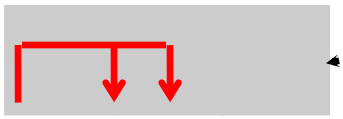
3.4 TECHNIQUES THAT HAVE CHANGED MY STYLE OF TEACHING

18. Use Textbook as a Set of Notes to Minimize the Amount of Writing Students Do In Class - Joint 11th
19. Make and Use Transparencies of Graphs, Tables, Rules, etc. So the Instructor does not waste Time Drawing or Writing Them on the Blackboard - 12th
20. Use Colored Chalk or Colored Markers on the Board - 16th
21. Create ***Alternative Methods*** For Those Topics that Cause Difficulty - 13th
22. Additional Voluntary Tutorials – 17th
23. Marking Scheme for All Tests (Available to Students) with Partial Credit throughout All Questions - Joint 11th
24. Constantly Asking Questions During Class - 18th
25. Using a Metalanguage with the TI-83 Calculator - 5th
26. Teaching Maple with Code Re-using, Sample Programs, and Answer Checking-***Being Tested***
27. The **AllCoursesInformationFile** in my computer area and accessible via the Internet - ***Being Tested***
28. Strategies to Develop a Rapport with Students - ***Being Tested***

4. AN ALTERNATIVE METHOD - COLLEGE ALGEBRA

The Arrow Method

The **Arrow Method** is a method which, unlike **FOIL**, allows a student to multiply out any of the algebraic expressions shown below using what I call **arrow sets**. The highlight below covers ***one* arrow set**. So **Example 1** has *two* arrow sets, one above the expression and one below, while **Example 3** has *three* **arrow sets**, one above and two below the expression. I draw each *arrow set* using chalk of a different color and write the resulting terms on the other side of the equal sign in the same color as the *arrow set*, before finally collecting up terms using white chalk. Even though the *arrow sets* below the expression in **Example 3** cross each other, there is no confusion because they are drawn using different colored chalk. Students frequently include the *arrow sets* even in the final! Some even draw them in color! I tested various ways of drawing the *arrow sets* and found the ones below the most effective.



1) $(5x - 2)(2x - 7)$ $= 10x^2 - 35x - 4x + 14$

$= 10x^2 - 39x + 14$

2) $(7x + 2)(x^2 + 3x - 9)$ $= 7x^3 + 21x^2 - 63x + 2x^2 + 6x - 18$

$= 7x^3 + 23x^2 - 57x - 18$

3) $(2x^2 - 5x + 7)(3x + 2)$ $= 6x^3 + 4x^2 - 15x^2 - 10x + 21x + 14$

$= 6x^3 - 11x^2 + 11x + 14$

4) $2x^3(3y + 2z)$ $= 6x^3y + 4x^3z$

5. ALTERNATIVE METHOD 2 - COLLEGE ALGEBRA

The Guaranteed Factor Method (GFM)

Many students have difficulty finding the two linear factors with integer coefficients of a second-degree polynomial (if they exist) i.e. finding the factors of a second-degree polynomial *relative to the integers*. The **Guaranteed Factor Method** uses a program, input by a student into the **TI-83** calculator, to find these factors for any second-degree polynomial of the form $\mathbf{Ax^2 + Bx + C}$. For example, if the two linear factors with integer coefficients of the second-degree polynomial $\mathbf{12x^2 + 7x - 10}$ are required, this

method will let ***any*** student find the expression **(3x – 2) (4x + 5)**. The output from the program will make it clear, if the polynomial **cannot** be factored relative to the integers. The following program, called **QUADPROG**, must be entered into the calculator first.

```
PROGRAM:QUADPROG
:Prompt A,B,C
:(-B+√(B² – 4AC))/
(2A)→P
:(-B–√(B² – 4AC))/
(2A)→Q
:Disp "ZEROS ARE
",P▶Frac,Q▶Frac
```

The following procedure finds the *roots* of $12x^2 + 7x - 10 = 0$ (or the *zeros* of $12x^2 + 7x - 10$) :

Step 1 $(3x - 2)(4x + 5) = 0$
Step 2 then either $(3x - 2) = 0$ or $(4x + 5) = 0$
Step 3 and thus either $x = \frac{2}{3}$ or $x = -\frac{5}{4}$

Step 1 contains the factors of the quadratic function $12x^2 + 7x - 10$ relative to the integers. It is this step that students have difficulty completing. When **A = 12**, **B = 7**, and **C = -10** are entered into **QUADPROG** the output is **Step 3**. Students can then proceed backwards to **Step 1** to obtain the factors of the quadratic function relative to the integers i.e.

Step 3 Output from **QUADPROG** : $x = \frac{2}{3}$ or $x = -\frac{5}{4}$
Step 2 then either $(3x - 2) = 0$ or $(4x + 5) = 0$=
Step 1 $(3x - 2)(4x + 5) = 0$

Therefore **(3x – 2)** and **(4x + 5)** are the factors of the quadratic function $12x^2 + 7x - 10$ relative to the integers. Now, using **QUADPROG**, every one of my students can find the factors of any quadratic function relative to the integers. During my *College Algebra* course last semester, one of my students said "***QUADPROG** is so cool*". This must be the ultimate accolade!

6. A SUMMARY OF PEER RESPONSIBILITY

All students in my courses work in groups of three (although there may have to be one or even two groups of two, depending on the number of students in a class). I call each group of students a ***partnership*** and each student in a *partnership* a ***partner***. I select three sets of questions from the end of each section of the textbook that will be covered during the course. I call one set of questions **Set A**, the second **Set B**, and the third **Set C**. When each student has completed his/her own set of questions, he or she ***marks*** **one** set of questions completed by **one** of their partners. Each partnership must then organize their work into one *joint workbook*. I call this strategy ***Peer Responsibility***.

One of the objectives of *Peer Responsibility* is to make students discuss the work with each other and to help one another throughout the course. The *marker* can prevent the *solver* from losing marks by identifying questions that are incorrect so that they can be corrected before I see them. If, when a solution reaches me, the solution is correct and the *marker* has marked it as correct, neither student loses any marks. ***Just as important***, the *marker* will not lose marks if the *solver* is unable or unwilling to complete the assigned questions correctly, because the *marker* only needs to recognize whether a question is right, wrong, complete, incomplete, or omitted.

Another objective of *Peer Responsibility* is to increase *student-instructor* interaction. Most students have never marked the work of another student before and some will require advice. The instructor is the most experienced marker, so students will come to him or her for advice. I never tell a student how to mark a question. I always make the student tell me what they are going to do and why they are going to do it. I then ask questions designed to make them think about what they have decided to do until they have solved the problem they were having.

Incidentally, I have always preferred the term *partnership* to *group* because to me the word *partnership* conveys the idea of working closely together. In England, if there were a group of people, who did not know each other, waiting at a bus stop, they would all ignore each other. Indeed I had been over here for several years before I got used to the fact that when walking around the campus, people I did not know would say "Hi" to me. Now when I return to England for a visit, I have to remember to ignore people around me that I do not know!

Marking the workbook is not as onerous a task as it might at first sound, because the solutions have already been marked, and good students will solve and mark most questions correctly. Also the instructor has complete control of how many questions he or she must mark in the workbook. *For each course, I carefully select questions for the workbook so that the questions are challenging and the number to be solved and marked is sufficient to get the partnership cooperating,* ***but*** *I have only 3 to 4 hours of marking to do at the end of* ***Session 1*** *and* ***Session 2****, and 2 to 3 hours of marking to do at the end of* ***Session 3****.* In short, there cannot be too many questions per student per session! So I use the questions on the *Example Tests* as a source of further practice, **BUT** these questions do **NOT** have to be marked by the instructor.

I write the Example Tests so that all the topics and concepts in that session are covered. College Algebra may require 25 questions on the Example Test to cover all the topics and concepts. Differential equations may require 14 questions etc. Two of these would be assignments; the remainder would be divided between the partners by the partners. Each partner completes those questions assigned to him or her; they then discuss their solutions with the other partner(s). I make it very clear that all the topics and concepts that could appear on the real test for that session are covered in the Example Test and the workbook problems. To reinforce the importance of the Example Tests, I tell my students that it is essential that they complete the Example Tests because, when I mark the real tests, I can tell who completed them and who did not. **I emphasize that there can be as much as a 20% difference between students who complete the Example Test and those who do not.**

The partnerships with good or keen students will divide up, solve and discuss the questions. There will always be some students who will not be very keen to do any additional work.

However, these students will usually be able to see the folly of not completing the Example Tests! Students use *Peer Responsibility* without using more of the instructor's time (except to answer questions when the partnership gets stuck!). I have found that students quickly learn that they will gain the most by cooperating and working together.

Note that you must never supply written solutions to the questions on the Example Tests. If you do your students will not come to you for help and they will not try to solve the questions themselves, they will just read the solutions, gaining far less than if they attempted to complete them on their own or with their partners. Also when they come to see you, let them tell you what they are doing, and then keep asking questions that push them in the right direction until their problem(s) are solved.

I make sure that my students know that if they need help, I am just a phone call away. If there are difficulties, I sort them out either in class, in *Additional Voluntary Tutorials*, or in my office hours. Note that to reduce my workload, I frequently use the same *Example Test* in 2 or more semesters.

Initially, I form all the partnerships on the first day the class meets using a form I refer to as the *Times Not Available Form*. Each student crosses out all the times on this form during the week when they could not meet their partners. When the forms have been completed, I tell them to walk around the room and find students who are free as often as possible when they are free. Students then sit together in class with their partners for the rest of the semester. The *Times Not Available Form* will usually get around 70% to 80% of the students in a class into partnerships that will be successful. However, it will not solve all the problems associated with students working in partnerships. So, usually after three weeks, I collect the workbooks and check to see if each student has completed and marked all the required work. I then re-arrange students in partnerships that are not likely to be successful, into new partnerships according to the following criteria :

1) I put the **workers** together;
2) I put the **non-workers** together;
3) I put students who **miss class** or **who do not follow the rules** together.

Each student can ***choose*** to be in any one of the above three groups. However, I emphasize that each student will gain the most academically and obtain the highest grade, by being a ***worker*** in a partnership with other ***workers***. I will allow only one exception. If ***both*** members of a partnership, or ***all*** three partners, for partnerships of three, request to stay together, then I will leave them together, even if one partner is way behind. Note that if the class divides precisely into partnerships of three, *I take two partnerships of three and divide them into three partnerships of two*. This is so that if a student(s) adds, I have a ready-made partnership in which to place him or her. Also if a student drops, in one of the partnerships of two, I can place the other student into one of the surviving partnerships of two. Partnerships should remain fluid throughout the course. If one partner wants to leave his/her partnership and join another they must be accommodated, *even if it is close to the end of the semester*. *A student must never be trapped by the structure of a course.*

To improve the quality of the work, the *solver* can obtain an unlimited number of bonuses from the workbook. It is also possible, although less frequent, for the *marker* to obtain bonuses. In

order to make each student try to obtain bonuses and improve the standard of their work, the marking scheme includes a *major unknown* over which they have no control. The Final is worth 40% of the total marks available for the course. Most students can see the wisdom of trying to obtain bonuses and improving the standard of their work, in case they have a bad day on the day of the Final.

I bring some completed workbooks from a previous semester along to the first day of class so my students can see what a workbook looks like. I, then, put them on reserve in the library so they can have another look later on if they want to. The workbooks I put in the library are from courses that are **NOT** running during the current semester – to prevent copying. Usually in the first week of class I assign some questions for the workbook. I recommend that these questions be completed over the first weekend of the semester. However, I tell students not to start marking until the second week of the semester, in case one of their partner's drops or a new student joins their partnership.

Almost every semester I receive at least one workbook from every class whose presentation is far superior to those of other partnerships. So that I can review the workbooks and allocate bonus marks for these workbooks, all workbooks are handed to me on the day of the Final. I record any bonus marks for the workbooks in a column in the *Attendance Register*, so that it is added to any attendance bonuses that have been accrued, and automatically transferred to the *Marks Register*. After the Final, I post a sheet of paper on my door and ask students to sign it if they want their workbook returned to them.

Full details about the *marking scheme* and *Peer Responsibility* are in a set of notes called "*A Guide to Partnerships*". On the first day of class, I tell my students to obtain a copy of it. I also tell them that there will be an ***open-book*** multiple-choice test on this set of notes, at the beginning of the second week of the semester. I refer to this test as the *Structure Test*. There is only one *Structure Test*. Every student in every class in every course takes the same *Structure Test*. I never change it. The day the students take the *Structure Test* is shown in the *Semester Plan* I hand out with the syllabus on the first day of class. While there are no make-up tests for *Test 1* and *Test 2* (the missed marks are added to the Final), I do let students take the *Structure Test* if they miss it, because I want them to understand the structure of the course.

There are **20** multiple-choice questions on the *Structure Test*, each worth **1** mark. These **20** possible marks are **bonus** marks (the maximum number of marks for the course is **1020**, assuming no other bonuses). I tell my students that they must have a **red pen** on the day the *Structure Test* is marked because they will be marking the test of the appropriate partner. Any student without a red pen loses **5** marks. It usually takes about **15** minutes to complete the test and about **10** minutes for the students to mark their partner's test. I encourage discussion during the marking of the test.

I start the test about **15** to **20** minutes before the ***end*** of a class and mark it at the beginning of the next class. There is good reason for this! If you start the test at the beginning of a class, you could lose the remaining class time because their will always be a few students who spend the entire class period completing the test. However, I noticed that the slower students finish the test very quickly when the end of the class arrives! Also marking the test at the beginning of the

next class period, gives those students in the class, who are less organized, a second chance to buy a red pen!

The *Structure Test* introduces students to marking the work of the correct partner for the first time while I am present, to resolve any problems. It also introduces students to the words *solver* and *marker*. Note that students must follow the rules when marking the work of their partner. If they do not, I deduct **1** mark per marking error from their *Structure Test* total.

7. THE SEMESTER PLAN AND THE THREE SESSIONS

Semester Plans list all the important dates associated with each type of assessment, for an entire 15-week semester plus Finals week, on one sheet of paper. There are two sets of *Semester Plans*, a fall set and a spring set. This is necessary because Spring Break makes all spring *Semester Plans* one week longer than fall Semester Plans. When the session lengths in a semester are the same, all fall *Semester Plans* are identical and all spring *Semester Plans* are identical (sessions are discussed later in this section). Creating a new *Semester Plan* from an existing one usually takes less than 10 minutes. Changing the date of the first Monday of the semester changes the weekday dates throughout a plan. This is described in the box below.

> NOTE : The weekday dates in all Semester Plans are set relative to the first Monday of the semester, the Monday of the first week of the Spring 2002 semester, (Cell Content = 01/07/2002). If this date is changed to 6th January, 2003, the Monday of the first week of the Spring 2003 semester, (Cell Content = 01/06/2003), then all the dates throughout the semester will be set correctly for the Spring 2003 semester. If this date is changed to 5th January, 2004, the Monday of the first week of the Spring 2004 semester, (Cell Content = 01/05/2004), then all the dates throughout the semester will be set correctly for the Spring 2004 semester, with February 29th included, since 2004 is a leap year etc.

I have found *Semester Plans* to be so useful that I use them in every course I teach and I always include a black and white copy of the relevant Semester Plan in each syllabus. I tell my students to remove it from the syllabus and keep it handy throughout the course. I also put a copy of each Semester Plan in my computer area. Many of my students have stated that they like having all the important dates, for an entire semester, listed on one sheet of paper, and make a color copy of the Semester Plan from my computer area. I include an example of a *Fall Semester Plan* on page 10 and a *Spring Semester Plan* on page 11.

In each Semester Plan, the date at the top of the worksheet, the second row, and the two (sometimes three) rows of cells immediately under the weekday and date are ***not*** write-protected. So their content can be changed without the need to unprotect the worksheet. All the other cells are write-protected so that the dates, which are formulae, cannot be overwritten accidentally. To add or delete rows (or columns) or change the content of any protected cell, the worksheet must first be unprotected. To unprotect the sheet, select: ***Tools/Protection/Unprotect Sheet***

To re-protect the work sheet, select: **Tools/Protection/Protect Sheet/OK**.

Due to the workbook (*Peer Responsibility*), I have divided the Semester into three parts so that my students can obtain feedback about the work in their workbooks before each test throughout the semester. I call the three parts *Session 1*, *Session 2*, and *Session 3*. They are shown in each *Semester Plan*. At the end of each session, I collect the workbooks and mark the solutions in the same way as I mark the solutions on the tests, so that students can see how I mark and also how to gain bonus marks. I also mark the marking. I then return the workbooks before each test is taken. *Session 3* usually ends at the end of the 14th week, instead of the end of the semester, in order to provide feedback to my students before the **Final**, and give me time to write the finals!

In order to stagger the marking during each semester I use Sessions of different lengths. Four schemes are shown in the table below. Many others schemes are possible. I usually teach four courses per semester, two *Statistics courses* and two other Mathematics courses. I use **Scheme 1** for one Maths course, **Scheme 2** for the second Maths course, **Scheme 3** for one of my *Statistics courses* and **Scheme 4** for the other Statistics course. After three years using these teaching methodologies with a total of about 350 students, I have always managed to complete the marking of each course in accordance with my semester plans. The numbers in brackets under the scheme number, indicate the length of each of the three sessions in weeks.

SCHEME 1 (455)	SCHEME 2 (454)	SCHEME 3 (554)	SCHEME 4 (653)
SESSION 1	**SESSION 1**	**SESSION 1**	**SESSION 1**
WEEK 1	WEEK 1	WEEK 1	WEEK 1
WEEK 2	WEEK 2	WEEK 2	WEEK 2
WEEK 3	WEEK 3	WEEK 3	WEEK 3
WEEK 4	WEEK 4	WEEK 4	WEEK 4
SESSION 2	**SESSION 2**	WEEK 5	WEEK 5
WEEK 5	WEEK 5	**SESSION 2**	WEEK 6
WEEK 6	WEEK 6	WEEK 6	**SESSION 2**
WEEK 7	WEEK 7	WEEK 7	WEEK 7
WEEK 8	WEEK 8	WEEK 8	WEEK 8
WEEK 9	WEEK 9	WEEK 9	WEEK 9
SESSION 3	**SESSION 3**	WEEK 10	WEEK 10
WEEK 10	WEEK 10	**SESSION 3**	WEEK 11
WEEK 11	WEEK 11	WEEK 11	**SESSION 3**
WEEK 12	WEEK 12	WEEK 12	WEEK 12
WEEK 13	WEEK 13	WEEK 13	WEEK 13
WEEK 14		WEEK 14	WEEK 14

NOTE : Sessions and schemes are only needed, if Peer Responsibility is being used in a course.

At the end of each session, students can use the **Excel** file ***YourGradeAssignments.xls*** to calculate their mark and grade. A copy of this file is in my computer area. It can be copied from my computer area onto a zip disk or a floppy disk and opened in **Excel** by any student at any time during the course.. It is discussed and displayed in *Section 2.4*. Each session stops before a

test to give students feedback before they take the real test. *Session 3* stops at the end of the penultimate week of term because I do not want to be marking *workbooks* when I need to write Finals. It also allows my students to use the ***YourGrade*** file to ***forecast*** the grade they will need in the Final to obtain the grade they want for the course.

8. AN EXAMPLE OF A SEMESTER PLAN FOR A COURSE WITH ASSIGNMENTS

The following Semester Plan is one that I am currently using in my *M117 – Calculus 1 course*. When the date of the first Monday of the semester is changed all of the dates throughout the semester plan are changed automatically. For example, if the 22 August (2005) in week 1 is changed to the 20 August (2006), all dates throughout the semester plan would change and the semester plan would then fit the Fall 2006 semester.

	FALL 2006 SEMESTER PLAN — Mike Bankhead M117DO - Calculus 1 : MWF - 11:00 to 11:50; T - 9:25 to 11:25 - P104				
	S E S S I O N 1				
	Monday 28-Aug	Tuesday 29-Aug	Wednesday 30-Aug	Thursday 31-Aug	Friday 1-Sep
1	Find Partners Copy "Guide"				Withdraw 100%
	Monday 4-Sep	Tuesday 5-Sep	Wednesday 6-Sep	Thursday 7-Sep	Friday 8-Sep
2	HOLIDAY *Labour Day*	STRUCTURE TEST (Buy a Red Pen!)	Mark Structure Test		Copy Example Test 1 Handout Qu. For Wb
	Monday 11-Sep	Tuesday 12-Sep	Wednesday 13-Sep	Thursday 14-Sep	Friday 15-Sep
3					Wb Due by 5 pm (Is Work Complete?)
	Monday 18-Sep	Tuesday 19-Sep	Wednesday 20-Sep	Thursday 21-Sep	Friday 22-Sep
4	Workbook Returned				
	Monday 25-Sep	Tuesday 26-Sep	Wednesday 27-Sep	Thursday 28-Sep	Friday 29-Sep
5			A1 and A2 Set		Withdraw 75%
	Monday 2-Oct	Tuesday 3-Oct	Wednesday 4-Oct	Thursday 5-Oct	Friday 6-Oct
6	*Copy "YourGrade"* NO CLASS	Add. Vol. Tutorial 11:25 to 12:10	Wb S1 Two-Day Rule A1, A2 Due by 5 pm		Wb S1 Due by 5 pm
	S E S S I O N 2				
	Monday 9-Oct	Tuesday 10-Oct	Wednesday 11-Oct	Thursday 12-Oct	Friday 13-Oct
7	HOLIDAY Half Term		Wb S1 Returned A1 and A2 Returned		
	Monday 16-Oct	Tuesday 17-Oct	Wednesday 18-Oct	Thursday 19-Oct	Friday 20-Oct
8	Progress Reports Due	TEST 1			Copy Example Test 2
	Monday 23-Oct	Tuesday 24-Oct	Wednesday 25-Oct	Thursday 26-Oct	Friday 27-Oct
9	TEST 1 RETURNED *Use "YourGrade"*				Withdraw 50% Withdraw W Grade
	Monday 30-Oct	Tuesday 31-Oct	Wednesday 1-Nov	Thursday 2-Nov	Friday 3-Nov
10			A3 and A4 Set	NO CLASS AMATYC Conference	
	Monday 6-Nov	Tuesday 7-Nov	Wednesday 8-Nov	Thursday 9-Nov	Friday 10-Nov
11		Add. Vol. Tutorial 11:25 to 12:10	Wb S2 Two-Day Rule A3, A4 Due by 5 pm		Wb S2 Due by 5 pm A3 and A4 Returned
	S E S S I O N 3				
	Monday 13-Nov	Tuesday 14-Nov	Wednesday 15-Nov	Thursday 16-Nov	Friday 17-Nov
12	Wb S2 Returned	TEST 2			Copy Example Final A5 and A6 Set
	Monday 20-Nov	Tuesday 21-Nov	Wednesday 22-Nov	Thursday 23-Nov	Friday 24-Nov
13	TEST 2 RETURNED *Use "YourGrade"*		HOLIDAY Thanksgiving		
	Monday 27-Nov	Tuesday 28-Nov	Wednesday 29-Nov	Thursday 30-Nov	Friday 1-Dec
14	Wb S3 Two-Day Rule		Wb S3 Due by 5 pm A5, A6 Due by 5 pm		
	END OF WORKBOOK				
	Monday 4-Dec	Tuesday 5-Dec	Wednesday 6-Dec	Thursday 7-Dec	Friday 8-Dec
15	Wb S3 Returned		A5, A6 Due by 5 pm	Add. Vol. Tutorial 11:00 to 12:00	*Forecast Final Grade* *Using "YourGrade"*
	F I N A L S W E E K				
M J B	Monday 11-Dec	Tuesday 12-Dec	Wednesday 13-Dec	Thursday 14-Dec	Friday 15-Dec
	M405B : 8:00 - 11:00 M117DO : 12:00 - 3:00			Add. Vol. Tutorial 11:00 to 12:00	M205AN : 8:00 - 11:00

9. THE STRUCTURE TEST

NAME OF SOLVER	NAME OF MARKER	COURSE #	# CORRECT

1)The word "initials", as used in this guide, means

- **a)** your normal initials written the way you would normally write them;
- **b)** the first letter of your first name followed by the first letter of your last name, using upper or lower case letters;
- **c)** the first letter of your first name followed by the first letter of your last name, in capital letters;
- **d)** None of the above.

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2) Assuming no bonus marks have been earned

- **a)** the total number of marks allocated for the workbook is the same as the number of marks allocated for one of the in-term tests;
- **b)** the total number of marks allocated for the workbook is the same as the total number of marks allocated for both in-term tests;
- **c)** the number of marks allocated for your solutions in your part of the workbook is the same as the number of marks allocated for both of the in-term tests;
- **d)** None of the above.

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3) The file you would use to calculate your mark and grade throughout the course is :

- **a)** a **Word 2000** file with filename **YourGradeAssignments**.
- **b)** a **Word 2000** file with filename **YourGradeProjects**.
- **c)** an **Excel 2000** file with filename **YourGradeAssignments**.
- **d)** an **Excel 2000** file with filename **YourGradeProjects**.

---

4) You will lose 4 marks if

- **a)** one of your solutions is wrong, but you complete a correct solution in accordance with the instructions on page 10 of the set of notes called "*A Guide to Partnerships*";
- **b)** your partner marks one of your solutions as wrong although it is in fact correct;
- **c)** you mark a solution, which is wrong, and it is wrong, although your partner completes a correct solution that you choose not to mark;
- **d)** None of the above.

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5) You will need to buy :

- **a)** three binders if there are three students in your partnership;
- **b)** two binders if there are two students in your partnership;

c) only one binder per partnership;
d) None of the above.

10. THE QUESTIONS FOR THE WORKBOOK WORKSHEET

I hand out a copy of the following Questions for the Workbook to all of students in my M117 – Calculus 1 course. The textbook we us is *Calculus – Early Transcendentals by James Stewart, 5th Edition*, published by Thomson Brookes/Cole. NOTE HOW FEW QUESTIONS EACH STUDENT MUST COMPLETE DURING EACH SESSION. *Always remember that you must mark all questions completed in the workbook!* The workbook is designed to force student to work together and to learn from and teach each other not to cause the instructor to die from overwork!

QUESTIONS FOR THE WORKBOOK

Fall 2006 : 16th October, 2006 *M117 - CALCULUS 1* *from Mike Bankhead*

SESSION 1

CH	SEC	SET A	SET B	SET C
1	1.1	NONE	NONE	NONE
	1.2	NONE	NONE	NONE
	1.3	NONE	NONE	NONE
	1.4	NONE	NONE	NONE
	1.5	NONE	NONE	NONE
	1.6	NONE	NONE	NONE
2	2.1	NONE	NONE	NONE
	2.2	6	4	8
	2.3	48 - Graph in Maple	48 - Graph in Maple	48 - Graph in Maple
	2.4	NONE	NONE	NONE
	2.5	NONE	NONE	NONE
	2.6	16	14	18
	2.7	NONE	NONE	NONE
	2.8	NONE	NONE	NONE
	2.9	28	30	26
3	3.1	NONE	NONE	NONE
	3.2	13	16	14

SESSION 2

3	3.3	NONE	NONE	NONE
	3.4	12	10	14
	3.5	43	45	44
	3.6	NONE	NONE	NONE
	3.7	49 (Graph in Maple)	50 (Graph in Maple)	49 (Graph in Maple)
	3.8	NONE	NONE	NONE
	3.9	**OMIT**	**OMIT**	**OMIT**
	3.10	NONE	NONE	NONE
	3.11	NONE	NONE	NONE
4	4.1	52	54	53
	4.2	NONE	NONE	NONE

SESSION 3

4	4.3	NONE	NONE	NONE
	4.4	22	29	23
	4.5	NONE	NONE	NONE
	4.6	**OMIT**	**OMIT**	**OMIT**
	4.7	10	4	17
	4.8	NONE	NONE	NONE
	4.9	14	13	18
	4.10	NONE	NONE	NONE
CH	SEC	SET A	SET B	SET C

11. THE MARKS REGISTER WITH THE 7 RIGHT-HAND COLUMNS AND EMERGENCY LINE

The Marks Register is designed to minimize the amount of work that the instructor must do to keep track of the marks and grades of all students in a class. The first worksheet in the Marks Register workbook explains, in detail, how to use the Marks Register.

FALL 2005 — **M117BO - CALCULUS 1** — **INSTRUCTOR - Mike Bankhead**

MARKS REGISTER FOR COURSES WITH ASSIGNMENTS

SESSION NUMBER			SESSION 1							SESSION 2							SESSION 3					FINAL RESULTS								
#	STUDENT NAME		ST	As1 Mk	As2 Mk	Wb1 Mk	T1 Mk	T1 Grd	S1 Mk	S1 Grd	As3 Mk	As4 Mk	Wb2 Mk	T2 Mk	T2 Grd	S12 Mk	S12 Grd	As5 Mk	As6 Mk	Wb3 Mk	S123 Mk	S123 Grd	Fin Mk	Final Grd	Tot Bon	Crse Mk	Crse Grd	LAST NAME	Wb S1	Wb S2	Wb S3	T1 Lost	T2 Lost	Fin Lost
1	ANDERS	*Gary*	18	23	19	80	60	D	75	C+	20	20	85	80	B-	82	B-	17	20	90	79	C+	75	C+	24	84	B	ANDERS	-16	-12	-8	41	21	65
2	ANTES	*Mike*	16	22	16	54	71	C	73	C	19	19	89	97	A	86	B	17	14	98	86	B	71	C	15	82	B-	ANTES	-37	-9	-2	30	4	73
3	BEST	*Betty*	15	23	16	71	75	C+	81	B-	20	19	95	97	A	91	A-	14	21	96	89	B+	82	B-	20	90	A-	BEST	-23	-4	-3	26	4	51
4	COLLINS	*Mary*	17	14	10	81	68	D	75	C+	20	18	79	53	F	72	C	17	17	93	71	C	62	D	21	73	C	COLLINS	-15	-17	-6	33	49	93
5	COLVIN	*Gwen*	18	14	16	86	62	D	74	C	20	20	84	79	C+	81	B-	15	18	96	79	C+	54	F	22	75	C+	COLVIN	-11	-13	-3	39	22	110
6	DARNELL	*Denise*	17	20	10	83	68	D	77	C+	20	20	96	67	D	80	B-	17	13	105	78	C+	61	D	26	78	C+	DARNELL	-14	-3	4	33	34	95
7	FERGUSON	*Sarah*	18	23	23	93	83	B	94	A-	22	23	98	87	B	96	A	20	16	101	93	A-	85	B	27	95	A	FERGUSON	-6	-2	1	18	14	44
8	GAROFALD	*Vera*	17	18	23	95	75	C+	87	B	20	20	89	83	B	89	B+	17	28	90	87	B	70	C	20	86	B	GAROFALD	-4	-9	-8	26	18	77
9	HIGGS	*Jeanna*	20	23	16	95	66	D	81	B-	20	20	78	35	F	69	D	13	23	85	67	D	47	F	19	67	D	HIGGS	-4	-18	-12	35	67	125
10	JACKSON	*Greg*	18	13	18	88	42	F	62	D	20	16	75	30	F	57	F	16	18	93	56	F	67	D	24	71	C	JACKSON	-10	-20	-6	59	73	83
11	KESSLER	*Maria*	14	18	19	90	57	F	73	C	20	20	88	66	D	76	C+	17	18	96	74	C	59	F	21	75	C+	KESSLER	-8	-10	-3	44	36	100
12	MEDFORD	*Amy*	16	24	3	76	94	A-	90	A-	20	17	91	58	F	82	B-	20	18	91	82	B-	58	F	17	76	C+	MEDFORD	-19	-7	-7	7	44	101
13	MEYER	*Bart*	16	22	25	94	71	C	87	B	20	20	104	81	B-	90	A-	17	22	98	87	B	91	A-	27	96	A	MEYER	-5	3	-2	30	20	31
14	MILLER	*Troy*	16	16	16	75	66	D	74	C	20	20	93	79	C+	82	B-	22	16	99	81	B-	38	F	25	69	D	MILLER	-20	-6	-1	35	22	144
15	POULTER	*Elizabeth*	19	26	26	88	84	B	95	A	20	20	96	97	A	98	A	21	12	93	95	A	94	A-	21	98	A	POULTER	-10	-3	-6	17	4	26
16	REINSTEDLER	*Rod*	15	13	17	90	86	B	90	A-	20	20	86	85	B	91	A-	16	18	96	89	B+	81	B-	25	90	A-	REINSTEDLER	-8	-11	-3	15	16	52
17	RENGERS	*Shannon*	15	16	20	89	71	C	82	B-	20	20	86	72	C	83	B	17	18	94	80	B-	77	C+	25	85	B	RENGERS	-9	-11	-5	30	29	62
18	SANDERS	*Ed*	14	19	8	85	64	D	72	C	20	19	68	41	F	65	D	15	21	90	65	D	65	D	11	71	C	SANDERS	-12	-26	-8	37	61	86
19	STONE	*Diane*	16	21	17	96	44	F	66	D	20	22	90	58	F	70	C	18	16	98	69	D	63	D	10	75	C+	STONE	-3	-8	-2	57	44	91
20	STOPHER	*Ken*	19	23	18	103	96	A	103	A	20	20	75	68	D	91	A-	15	18	104	89	B+	90	A-	27	95	A	STOPHER	2	-20	3	5	33	35
21	TARRANT	*Jeanna*	18	14	17	91	67	D	79	C+	20	23	90	42	F	73	C	21	16	103	71	C	67	D	25	78	C+	TARRANT	-7	-8	2	34	60	82
22	THOMAS	*Clara*	16	14	20	91	58	F	72	C	20	20	84	32	F	64	D	15	21	89	63	D	63	D	11	71	C	THOMAS	-7	-13	-9	43	71	90
23	WARNER	*Whitney*	19	24	17	89	67	D	80	B-	20	20	75	87	B	84	B	19	6	94	83	B	87	B	10	88	A	WARNER	-9	-20	-5	34	14	40
24	WARRINGTON	*Robyn*	16	23	21	108	80	B-	95	A	18	20	95	77	C+	92	A-	21	18	105	89	B+	60	D	27	84	B	WARRINGTON	6	-4	4	21	24	98
25	YOUNG	*Scott*	18	21	15	94	76	C+	86	B	16	20	101	71	C	85	B	17	13	93	83	B	80	B-	15	87	B	YOUNG	-5	1	-6	25	30	54
26	ZACHARY	*Erica*	16	24	15	100	91	A-	99	A	20	17	89	81	B-	94	A-	16	21	100	92	A-	72	C	27	89	B+	ZACHARY	0	-9	0	10	20	72
MEANS			17	20	17	88	71	C	82	B-	20	20	88	70	C	82	B-	18	18	96	80	B-	70	C	21	82	B-	MEANS	-10	-10	-4	31	33	77
NUMBER OF STUDENTS			26	26	26	26	26		26		26	26	26	26		26		26	26	26	26		26		26	26		# OF STUDENTS	26	26	26	26	26	26
EMERGENCY FORMULAE																									0			0						

12. THE YourGradeAssignments WORKSHEET

The *YourGradeAssignments* Excel worksheet allows students to keep track of their own marks and grades throughout a course. When the workbook is first opened the instructions on how to use the *YourGrade* worksheet is displayed. The worksheet below is displayed when the *YourGrade* tab, at the bottom of the screen, is selected. As a student enters their marks, formulae in those cells containing the words *Session* and *Mark*, cause the total mark at the end of each session to be calculated and displayed, while those cells containing the word *Grade* will display the grade corresponding to the appropriate mark cell. Any one of the following ten grades can be displayed in the grade cells :

F, D, C, C+, B–, B, B+, A–, A, A+

CALCULATING AND FORECASTING YOUR GRADE
by
Mike Bankhead
(For Courses With Assignments)

N A M E	

Structure Test Mark (Out of 20 - This is a Bonus Mark)	

COURSE GRADE AFTER COMPLETING SESSION 1

Assignment 1 (Out of 20)		Session 1 Wb Total (S_T+M_T)	
Assignment 2 (Out of 20)		% for Wb in Session 1	
Test 1 Mark (%)		Session 1 Mark (%)	
Test 1 Grade		Session 1 Grade	

COURSE GRADE AFTER COMPLETING SESSIONS 1 AND 2

Assignment 3 (Out of 20)		Session 2 Wb Total (S_T+M_T)	
Assignment 4 (Out of 20)		% for Wb in Session 2	
Test 2 Mark (%)		Sessions 1+2 Mark (%)	
Test 2 Grade		Sessions 1+2 Grade	

COURSE GRADE AFTER COMPLETING SESSIONS 1, 2, AND 3

Assignment 5 (Out of 20)		Session 3 Wb Total (S_T+M_T)	
Assignment 6 (Out of 20)		% for Wb in Session 3	
Sessions 1+2+3 Mark (%)		Sessions 1+2+3 Grade	

FORECASTING YOUR COURSE GRADE FROM YOUR FINAL MARK

Total Bonuses		Estimated Course Mark (%)	
Estimated Final Mark (%)		Estimated Course Grade	

13. EXAMPLES OF THINKING PROBLEMS

The Lead in a Boat Problem

A **man** and a **piece of lead** are in a *boat* in the middle of a totally enclosed lake. On a partially submerged stick in the bank, there is a **mark** showing the *level of the lake* while the **man** and the **lead** are *in the boat*. The man then throws the **lead** into the lake (*no water enters or leaves the lake*). Does the level of the lake go **up**, **down**, or **stay the same**?

The Five Hat Problem

There were **three men** in a room. **One** was ***blind*** and the other **two** were ***blindfolded***. On a table in the room there were **five hats**, ***three* gold hats** and ***two* silver hats**. Each man picked a hat off the table and placed it on his own head. ***Clearly, no one knew if his own hat was silver or gold***. *The remaining two hats were removed from the room.*

The first **man took** off his *blindfold* and saw the hats the other two men were wearing but **not** his own. He said :

"I do not know if my hat is silver or gold"

He put his blindfold back on.

The **second man** took off his *blindfold* and saw the hats the other two men were wearing but **not** his own. He said :

"I do not know if my hat is silver or gold"

He put his blindfold back on.

The **blind man** then said :

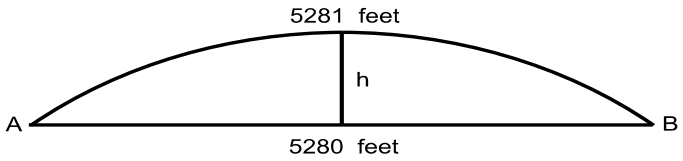
"I know the color of my own hat"

He then **correctly** identified the color of his own hat.

Was the **blind mans' hat *silver*** or ***gold*** and how did he know its color?

The Railway Problem

There is exactly ***one mile*** (**5280 feet**) of *level* railway track between two points **A** and **B**. One foot of track is added (**a total of 5281 feet**) to the existing track in such a way that the new track forms *an arc of a circle* between **A** and **B**. Estimate the maximum height



of the new track above the old. This height is **h** in the diagram below.

The Cylinder and Sphere Problem

A right cylindrical hole 6 inches in height is drilled through the centre of a sphere. What is the volume of material remaining?

14. JOINT PROJECT 1 : THE NORMAL DISTRIBUTION

Your *partnership* must collect **50** data values for a quantitative variable that you believe will be normally distributed. Draw *ONE* histogram of your distribution and plot the associated normal curve on this histogram, *even if the Normal Distribution is not an appropriate model for the observations you have obtained. Note that there is no need to draw a separate histogram without the normal curve on it.* State and show, clearly, the coordinates you used to plot the associated normal curve on the histogram. Draw a **Normal Quantile Plot** and use it to determine whether a normal curve would be a good mathematical model for your data. Justify your conclusion in your written report *and* in your presentation to the class. There is no penalty if the distribution you have obtained *cannot* be modeled by the Normal Distribution – just say so!

DO NOT COPY DATA FROM THE INTERNET OR FROM ANY OTHER SOURCE.

MARKING SCHEME AND INSTRUCTIONS

Each *partner* will get the ***same*** mark based upon the following *marking scheme* :

Correct Procedure and Analysis	**40 marks**
Written Presentation	**20 marks**
Oral Presentation	**20 marks**
Visuals	**20 marks**
TOTAL MARKS FOR JOINT PROJECT	**100 MARKS**

1) The report should be **typed** using **word processing software** such as **Word**, one per *partnership*, should include a description of your topic, how you collected data, the original data, any graphs, and an explanation of what you are trying to do in your study. Discuss any factors, which may affect the validity of the study. Hand in **TWO** copies of your report. One I keep and one I return to you.

2) A representative of each *partnership* will present a **BRIEF** report on the topic to the class (it should be about **5 minutes** long). ***DO NOT READ YOUR REPORT***. You should describe what your partnership did, what you discovered, and the conclusion your *partnership* reached. The visuals used during your presentation can be hand-drawn or created using software such as **Powerpoint**.

3) ***Please note*** **that in order to obtain the marks for the oral, you *MUST* be in attendance when your *partnership* presents their work to the class, even if you are not giving the oral.** ***Students who are absent, when their partnership presents their work to the class, will receive zero for the oral.***

4) **NOTE**: The **Division of Work Form** ***MUST*** be completed by *each partner individually* and included as the final page of the report you want me to mark. You can make a copy of it from the one in the **M205** sub-directory in my computer area.

NOTE: I WILL NOT MARK YOUR WORK IF THE TOPIC SELECTED BY YOUR PARTNERSHIP INVOLVES ANYTHING THAT IS ILLEGAL OR PUTS ANY STUDENT OR ANY MEMBER OF THE COMMUNITY IN DANGER.

Example 1 – The Normal Distribution

a) The Potato Gun Project

This *partnership* found the instructions for building a **potato gun** on the **Internet**, so they built one. It was made out of PVC piping four inches in diameter and about 6 feet long. At one end there was a special section about 6 inches in diameter and 12 inches long into which hair lacquer could be squirted and ignited. Hair lacquer was the propellant. They went to a park and shot a potato out of it 60 times, measuring the distance traveled each time. The objective was to determine if the distance traveled was normally distributed. I was amazed to learn that this gun could shoot a ***softball***-sized potato **400 feet!** They were very keen to demonstrate the capabilities of their newfound toy. On the day of their oral, they arrived with the gun ready to shoot a large potato out of the classroom window and over the nearest building! While I was very interested to see what it could do, I would not let them blast a potato over the top of our new library! Even their assurance that it was very accurate and they could hit the Dean at 400 feet failed to persuade me to let them try it (tempting though!).

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b) The Speed of 18-Wheelers on the Freeway Project

In this project the partnership thought that the speed that 18-wheelers maintained on the freeway some miles from the city center would be normally distributed. They selected the fastest of the three cars they owned and drove along the freeway looking for 18-wheelers. When they spotted one, the student driving came up alongside the 18-wheeler. A second student shouted faster or slower to the driver, until he judged that their car was travelling at the same speed as the 18-wheeler. He then shouted OK and the third student read and recorded the speed on their speedometer. They did this with 60 different 18-wheelers. I was horrified when they described in their oral what they had done. The data they had collected showed that some of the 18-wheelers had been traveling at over 90 mph and they had had to catch up with it and then match their speed to it. *After this project I make it clear to all students that any topic selected must not put any student or any member of the community in danger*. I noted that the minimum of their distribution was much greater than the posted speed limit while the standard deviation was fairly small!

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c) The Koosh Ball Project

A Kooshball Slingshot is a toy that throws a Kooshball. The toy maker claimed that it could hurl the ball over 50 feet. This partnership thought that the distance the slingshot threw the kooshball would be normally distributed. They also wanted to see if it could hurl the kooshball over 50 feet, as claimed by the toy maker. One member of the partnership practiced with it first and when he thought he was competent they used the slingshot 50 times and measured the 50 distances. They took a large number of precautions to guard against lurking variables. Their distribution included a few suspected outliers both large and small, but was otherwise remarkably symmetric. Later on in the course they were able to use their data to determine that the probability of the koosh ball flying 50 feet or more was **0.000000000000017** - in short ***never***!

15. JOINT PROJECT 2 : LEAST SQUARES REGRESSION LINE

The task of each *partnership* is as follows :

Your partnership must select two quantitative variables whose relationship you believe can be modeled by a straight line. Collect a minimum of **20** pairs of data. Draw a scatterplot of your data together with any other graph you feel appropriate. Compute the least squares regression line and draw it on your scatterplot. Compute any other values that you believe are relevant to your study. Explain clearly what you were trying to do, any assumptions you made, and your conclusion (there is no penalty if the variables you select *cannot* be modeled by a straight line – just say so!)..

DO NOT COPY DATA FROM THE INTERNET OR FROM ANY OTHER SOURCE.

MARKING SCHEME AND INSTRUCTIONS

Each *partner* will get the ***same*** mark based upon the following *marking scheme* :

Correct Procedure and Analysis	**40 marks**
Written Presentation	**20 marks**
Oral Presentation	**20 marks**
Visuals	**20 marks**
TOTAL MARKS FOR JOINT PROJECT	**100 MARKS**

1) The ***typed*** report, one per *partnership*, should include a description of your topic, how you collected data, the original data, any graphs, and an explanation of what you are trying to do in your study. Discuss any factors, which may affect the validity of the study.

2) A representative of each *partnership* will present a **BRIEF** report on the topic to the class (it should be about **5 minutes** long). ***DO NOT READ YOUR REPORT***. You should describe what your partnership did, what you discovered, and the conclusion your *partnership* reached.

3) Hand in **TWO** copies of your work. One I keep and one I return to you.

4) *Please note* that in order to obtain the marks for the oral, you ***MUST*** be in attendance when your *partnership* presents their work to the class, even if you are not giving the oral. *Students who are absent, when their partnership presents their work to the class, will receive zero for the oral.*

5) The final page of your report ***MUST*** provide a complete list of the work that each partner contributed to the project.

NOTE : I WILL NOT MARK YOUR WORK IF THE TOPIC SELECTED BY YOUR PARTNERSHIP INVOLVES ANYTHING THAT IS ILLEGAL OR PUTS ANY STUDENT OR ANY MEMBER OF THE COMMUNITY IN DANGER.

Example 2 – Least Squares Regression Line

a) The Length of an Airplane against the Distance Flown Project

This group built **15 model planes** with each plane a different length. The shortest plane was **14 centimeters long**, the next **15 centimeters long**, etc., up to the longest at **28 centimeters long**. The partnership then flew each plane five times to obtain the average distance traveled. The objective was to determine if a linear model would accurately predict the distance that a model plane of a particular length would travel, on the y-axis, from the length of a plane, on the x-axis. This partnership also carried out a **residual analysis**. Since **residual analysis** was not part of the course at that time, they had to go to the library to find out how to do it. This partnership found that while the relationship between the distance flown and the length of a plane could not be modeled by a straight line, it could be modeled with a parabola with the maximum distance flown corresponding to a plane with a length of 20 centimeters.

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b) The Eggs and Splatter Project

Another group bought **fifteen eggs** and, using a ladder, dropped them from **fifteen different heights**. They then measured the **maximum width** of the **splatter on the ground**. The objective was to determine if a linear model would accurately predict the **maximum splatter** given the **height** from which the egg was dropped. They were careful to reduce the effect of **lurking variables** while obtaining the measurements. For example, one member of the group dropped all the eggs making sure the orientation of each egg was the same before it was dropped, another member of the group measured the width of the

splatter, while the third member of the group recorded the measurements. It was amazing to see how well the least-squares line fitted the data on their "*splatterplot*" (their idea - not mine!). The **correlation coefficient**, **r**, was **0.998** with $\mathbf{r^2 = 0.996}$.

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c) The Typing Errors against the Number of Beers Consumed Project
(*Videotape was included with this Project*)

This partnership consisted of two boys and one girl called Katie (the name has been changed to protect the guilty!). Katie was a very competent typist. The partnerships hypothesis was that there would be a linear relationship between the number of typing errors and the number of bottles of beer consumed. First the partnership selected a paragraph that contained about 100 words. When Katie was ready to type a video camera was turned on and she typed the paragraph. They counted the number of typing errors that Katie had made. Katie was then given a bottle of beer to drink. They waited ten minutes, Katie typed the paragraph again and the number of typing errors counted. Katie drank another bottle of beer. They waited another ten minutes and so on. This process was suppose to be repeated until 20 pairs of values were obtained. While the video made it clear that all three students had a hilarious time throughout the experiment, I was appalled at their choice of topic. Not only were all three students under 21, so what they had been doing was illegal, I also felt that it was dangerous. They were unable to complete the experiment anyway, because after about 14 bottles of beer, Katie fell off the chair. She then had to be supported on the chair and before the end of the experiment she was quite incapable of typing anything. The following morning Katie discovered just how bad an idea this experiment was! *I now make it clear to all my students that all topics selected must not involve any illegal activity*.

THE DIVISION OF WORK FORM
(One Copy per Partnership at the END of the Copy you want me to Marked)

PROJECT # ☐

NAME OF PARTNER		**State what you did below**
NAME OF PARTNER		**State what you did below**
NAME OF PARTNER		**State what you did below**

YOUR MARK FOR THIS PROJECT

All projects are marked out of 100. If you completed your one-third of the work and this project obtained exactly 100 marks, you get 100 marks. If you did more than one third of the work you will receive ***more than*** 100 marks and if you completed less than one third of the work you will receive ***less than*** 100 marks. For example, if one partner does nothing, the allocation of marks would be **150**, **150**, **0**. How much is your contribution to this project worth? Enter it in the space provided in the table below the question mark.

PLEDGE

We, the undersigned, agree that the allocation of 300 marks (200 for partnerships of 2) in the following table, reflects the true amount of work completed by each partner in this project.

PARTNER	IF ⅓ EACH	?	SIGNATURE (Do *NOT* sign for your partner(s))
1	100		
2	100		
3	100		