1 Introduction

COSC1002/1902 provides an introduction to scientific problem solving using the programming language C. The scientific problems addressed will be drawn from a wide variety of disciplines, and no previous programming experience in C (or any other language) is expected. The emphasis is on problem solving rather than programming, with the aim of providing an introduction to the use of computers in science for students with diverse backgrounds and interests.

COSC 1902 students will share the same lecture and practical sessions as COSC 1002 students. However, COSC 1902 students will be given some alternative problems in the practical sessions and will be introduced to some more advanced numerical procedures.

1.1 Assumed Knowledge and Prohibitions

It is assumed that students have completed HSC Mathematics, Linear Algebra
Recommended concurrent units of study for COSC1002: COSC1001
Recommended concurrent units of study for COSC1902: COSC1901
COSC1002 may not be counted with COSC1902

2 Course Aims, Learning Objectives and Graduate Attributes

2.1 Course Aims

The programming language C is widely used in the natural sciences, and has been chosen for this unit. You will not be expected to master advanced aspects of the language, but you will be expected to attain a basic competency in C sufficient to write programs to solve simple but realistic problems arising in the natural sciences. Examples of the types of problems you will solve include calculating the maximum traffic throughput of a road, describing the populations of predator-prey species, and determining the frequency at which a hot object radiates most strongly. The associated numerical techniques that you will learn include methods for numerically evaluating integrals, for solving differential equations, and for finding the roots of functions. You will also learn how to construct simple models to describe physical systems.

2.2 Learning Outcomes

After successfully completing this unit, you should be able to demonstrate:

1. the ability to solve scientific problems using a computer, including understanding a mathematical model of a system, using a computer to implement and solve the model for given parameters, and interpreting the results;

2. to attain a level of competency in the programming language C, including understanding and being able to use variables and arrays, understanding and being able to use control structures involving logical statements, being able to read/write from/to a file and understanding and being able to write functions;

3. the understanding and ability to apply basic numerical methods, for example procedures for numerical root finding, integration, and solution of ordinary differential equations;
4. to understand and be able to implement and apply basic numerical methods, for example procedures for numerical root finding, integration, and solution of ordinary differential equations;
5. to understand some of the ways in which computation can lead to misleading results, including a model being invalid, and numerical errors such as floating point-rounding error;
6. an appreciation of how a computer may be used to solve scientific problems, and;
7. some ability to solve such problems using the programming language C.

2.3 Graduate Attributes

Graduate Attributes are generic attributes that encompass not only technical knowledge but additional qualities that will equip students to be strong contributing members of professional and social communities in their future careers. The overarching graduate attributes identified by the University relate to a graduate’s attitude or stance towards knowledge, towards the world, and towards themselves. These are understood as a combination of five overlapping skills or abilities, the foundations of which are developed as part of specific disciplinary study. For further details please refer to the Science faculty website at: http://www.itl.usyd.edu.au/graduateAttributes/facultyGA.cfm?faculty=Science
C5. Work as a member of a team, and take individual responsibility within the group for developing and achieving group goals. 7

C6. Take a leadership role in successfully influencing the activities of a group towards a common goal. 7

D Ethical, Social and Professional Understanding

D1. Demonstrate an understanding of the significance and scope of ethical principles, both as a professional scientist and in the broader social context, and a commitment to apply these principles when making decisions. 5

D2. Appreciate the importance of sustainability and the impact of science within the broader economic, environmental and socio-cultural context.

E Personal and Intellectual Autonomy

E1. Evaluate personal performance and development, recognise gaps in knowledge and acquire new knowledge independently. 3, 4

E2. Demonstrate flexibility in adapting to new situations and dealing with uncertainty. 4

E5. Demonstrate openness and curiosity when applying scientific understanding in a wider context.

3 Study Commitment

Students enrolled in any 3-credit point unit of study offered by the Faculty of Science should consider spending up to 6 hours per week on that unit during the 13 teaching weeks and the study vacation. In COSC 1001/1901 this involves:

Lectures

11 one-hour lectures. Lectures will include computer simulations and demonstrations, and class discussions. Lecture notes are provided.

Laboratory Work

11 two-hour practical sessions in a computational science laboratory, based on and supporting the lecture modules. You work in pairs at a computer on a selection of qualitative and quantitative questions and problems. Practical session notes describing the exercises will be provided, and tutors are present to assist you. The practical sessions start in week two of semester.

Independent Study

You are expected to do up to 3 hours (per week) of independent study. Use this time to:

- read through and understand your notes and relevant sections of the recommended references
- complete the assignments
- study for the written exam and practical tests
In class activities | Hours
--- | ---
Lectures (11 @ 1 hr each) | 11
Laboratory sessions (11 @ 2 hrs each) | 22
Total | 33

Independent Study | Hours
--- | ---
Reading of text for lectures (11 @ 0.5 hr each) | 5.5
Reading of lecture notes after lectures (11 @ 0.5 hr each) | 5.5
Revision and self assessment (12 @ 1 hr each) | 11
Assignment (1 @ 3 hr each) | 3
Preparation for practicals (11 @ 0.5 hr each) | 6
Total | 31

Study Tips

If you attend classes regularly and involve yourself in all of these learning experiences, you will gain a good understanding of the course work. This will have a considerable impact on your exam preparation and performance.

This is an introductory course and no prior programming knowledge is assumed. Mathematical techniques such as algebra and basic calculus will be used during the course, and hence HSC Mathematics is assumed knowledge. If you are experiencing difficulties with mathematics during the unit please inform your lecturer and seek assistance from the Mathematics Learning Centre in the Carslaw building.

Good study habits are also very important - we offer some suggestions on our Learning Physics web page (http://sydney.edu.au/science/physics/current/learningphysics.shtml).

4 Learning and Teaching Activities

Class Timetabling

Lectures and Practicals

There is a single lecture stream for all students in COSC1002/1902. There will be two streams of the practical sessions, and you will be scheduled into one of these.

<table>
<thead>
<tr>
<th>Session</th>
<th>Location</th>
<th>Times</th>
<th>Start Date</th>
<th>End Date</th>
</tr>
</thead>
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<tr>
<td>Lecture</td>
<td>Physics LT5</td>
<td>Mon 9am</td>
<td>Mon 25 July</td>
<td>Mon 17 Oct</td>
</tr>
<tr>
<td>Practical Class 1</td>
<td>Carslaw 177, Computational Science Lab</td>
<td>Wed 3-5pm</td>
<td>Wed 3 Aug</td>
<td>Wed 26 Oct</td>
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<tr>
<td>Practical Class 2</td>
<td>Carslaw 177, Computational Science Lab</td>
<td>Thurs 9-11am</td>
<td>Thurs 4 Aug</td>
<td>Thurs 27 Oct</td>
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</table>

There are no classes over the mid-semester break (Monday 24 September to Monday 1 October inclusive).
LECTURE OUTLINE

The following outline for the semester lists specific objectives that define what you should learn and understand. Understanding a term or concept means that you should be able to:

- explain its meaning in writing and give examples;
- interpret it correctly when you read or hear it;
- use it correctly in your writing; and
- apply it correctly to examples and problems.

The outline also briefly describes the kind of science problems you will encounter, and lists what sections of the recommended references are relevant.

Week: 1

Relevant parts of recommended references: Chapters 1,2 of Gottfried

- Understand basic C programming concepts and constructs, including the “main” program, the role and nature of variables, data types, the use of define directives, simple input/output to the screen, and iteration using a for loop
- Understand the procedure for compilation and execution of C codes under Linux
- Be able to write simple codes involving evaluation of equations, e.g. to convert scientific units, and to calculate the braking distance of a car

Week: 2

Relevant parts of recommended references: Chapters 3,6 of Gottfried

- Understand the properties of floating point numbers and some of the problems of floating point accuracy
- Understand floating point exceptions
- Understand and be able to use control structures and their associated logic in C
- Recognise situations when rounding error becomes important in numerical calculations, and understand some ways to avoid this problem
- Be able to use the maths library in C codes
- Understand and be able to apply methods to numerically solve the quadratic equation

Week: 3

Relevant parts of recommended references: Chapters 7,12 of Gottfried

- Understand the procedure for writing user-defined functions in C
- Write a variety of user-defined functions useful in scientific contexts
- Write data to a file using redirection
- Understand the use of global variables
- Be able to read in and plot datasets, and plot functions using gnuplot
- Interpret data in plots produced with gnuplot
- Solve science problems e.g. involving probability by writing and applying user-defined functions

Week: 4

Relevant parts of recommended references: Chapters 9,12 of Gottfried

- Understand and be able to use arrays in C
- Read data from a file using redirection
- Understand the method for passing arrays to functions in C
- Understand and be able to implement the trapezoidal rule for numerical integration
- Read-in and manipulate (including integrating) a variety of simple scientific datasets to solve problems, e.g. determine distance travelled given a table of instantaneous speeds
Week: 5

Relevant parts of recommended references: Chapter 16 of Press et al.

- Understand first order ordinary differential equations (ODEs) and the concept of an initial value problem
- Understand how first order ODEs appear in simple science problems, e.g. the description of population growth
- Understand the use of a direction field to provide qualitative information about the solution to a first order ODE
- Understand the use of non-dimensionalisation in the context of ODEs
- Understand and implement Euler's method to solve first order ODEs
- Write codes to solve scientific problems involving first order ODEs, e.g. to model population growth

Week: 6

Relevant parts of recommended references: Chapter 16 of Press et al.

- Understand the use of first order ODEs to model systems in science, e.g. the progress of a chemical reaction
- Understand the importance of numerical accuracy and stability in the solution of first order ODEs, and be able to perform a simple test for accuracy
- Understand a criterion for local stability of a first order ODE
- Understand the origin of second order Runge-Kutta, a more accurate scheme for integrating ODEs than Euler’s method
- Write codes to solve scientific problems involving first order ODEs, e.g. to model the flight of a rocket

Weeks: 7 & 8

Relevant parts of recommended references: Chapter 16 of Press et al.

- Understand the relationship between numerical integration and the solution of a first order ODE, and be able to numerically integrate a function by solving an ODE
- Understand the method of treatment of coupled first order ODEs
- Understand the use of phase space to visualise solutions to higher order ODEs
- Understand a general procedure for treating higher order ODEs
- Understand the use of higher order ODEs to model systems in science, e.g. interacting populations
- Write codes to model scientific problems involving higher order ODEs and understand and be able to modify the models, e.g. predator-prey systems

Weeks: 9 & 10

Relevant parts of recommended references:

- Understand difference equations
- Understand a variety of scientific models which give rise to difference equations
- Understand some details of the behaviour of nonlinear difference equations, e.g. the logistic map
- Write codes to numerically solve problems involving difference equations, e.g. loan amortisation

Weeks: 11 & 12

Relevant parts of recommended references: Chapters 9,10 of Press et al.

- Understand the bisection method for numerical root finding for a function of one variable
- Understand the Newton-Raphson method for numerical root finding for a function of one variable
- Understand the relative advantages and disadvantages of the two root-finding methods
- Numerically solve various transcendental equations that arise in scientific problems, e.g. to locate the peak of the Planck spectrum
5 Teaching Staff and Contact Details

<table>
<thead>
<tr>
<th>Unit Coordinator</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr Pulin Gong</td>
<td><a href="mailto:p.gong@physics.usyd.edu.au">p.gong@physics.usyd.edu.au</a></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Teaching Staff</th>
<th>Email</th>
<th>Room</th>
<th>Phone</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr Joachim Schmidt</td>
<td><a href="mailto:jschmidt@physics.usyd.edu.au">jschmidt@physics.usyd.edu.au</a></td>
<td>Physics, Room 226D</td>
<td>9036 7960</td>
<td></td>
</tr>
</tbody>
</table>

6 Learning Resources

Lecture Notes
Lecture notes are provided on the eLearning site. The lecture notes are intended to assist with your learning in the unit, but they are not a replacement for attending lectures. The lectures may contain material not reproduced in the notes.

Practical Session Notes
Notes providing problems and guidance for the practical sessions will be provided at the start of each prac session. The notes include a variety of scientific problems from a broad range of disciplines, illustrating the theory presented in the lectures.

Example Codes
All codes from the lectures are available on the eLearning site.

Recommended References
There is no textbook as such. The following are recommended references.

The required knowledge of the C programming language is described in the book Schaum's Outlines - Programming with C by B. Gottfried (McGraw-Hill 1996), which is available from the Co-op Bookshop.


Web Resources
The ‘Current Student’ link on the School of Physics web page (http://sydney.edu.au/science/physics) provides resources to help you with your studies. Please spend time getting acquainted with this site, and
Email
The University provides you with email access based on your username. We may use this email address to provide you with important information regarding this unit of study. **We expect you to periodically read your email account or to forward mail from it to an account you do read (eg a hotmail account).**

Where to go for help
If you need help, you can:

- as a first step, always check your unit eLearning pages for information, documents and links
- ask other students using the Discussion Board on the unit eLearning page
- go to the Physics Student Services Office, Room 210 in the Physics building, phone 9351 3037
- ask your lecturer or tutor
- consult one of the many services provided by the University, such as the Maths Learning Centre. These can be found by choosing *Junior Physics Resources and Links* from the unit eLearning page or your *MyUni* pages (http://sydney.edu.au/myuni).

**7 Assessment Tasks**

Assessment

Assessment tasks are intended to allow you to demonstrate what you have learned related to the goals of this unit. They also serve to encourage you to work with the material, but should not dominate your approach to learning. See them as another learning activity, accompanying and complementing those listed earlier.

Assessment of this unit of study is based on achievement of specific learning objectives (listed earlier) demonstrated in a combination of assignments, tests, examination and laboratory work. Satisfactory performance in all aspects of assessment is necessary to ensure a pass in this unit.

In addition, students in physics must be able to express themselves accurately by clear, efficient use of the English language in their written work. Spelling, grammar, punctuation and correct use of language will be taken into account when written reports and examination work are assessed. Students should refer to the University’s WriteSite (http://writesite.elearn.usyd.edu.au/) if they are looking for guidance on grammar and other aspects of academic and professional writing.

You should be familiar with the new University Assessment policy, which can be found at http://sydney.edu.au/ab/policies/Assessment_Policy_2011.pdf

**7.1 Summative Assessments**

<table>
<thead>
<tr>
<th>Assessment Task</th>
<th>Percentage Mark</th>
<th>Due Date</th>
<th>Learning Outcomes</th>
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</thead>
<tbody>
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</table>
Weekly Practical Sessions
Assessment in the practical sessions is based on successful completion of the practicals, and on a progress test and practical exam. Each week you will work with a partner on a set of exercises, and tutors will mark off your completion of the exercises at a number of checkpoints on the practical session sheets. You are expected to keep a personal logbook, in which you record rough working, and details of how you arrived at the answers, but this will not be marked as such (although tutors may ask to look at your working). You will only receive full marks for the practical session exercises if all checkpoints have been marked off, and checkpoints will only be marked off during practical sessions. Students will not receive marks for exercises completed outside of the practical sessions.

Assignment
The assignment will consist of a few questions. Worked solutions to the assignment questions will be posted on the unit eLearning pages when the marked assignments are returned. You may submit the assignment by yourself or together with your partner from the practical sessions. If you submit as a pair, please add a cover sheet (available from Physics Student Services, Room 210) signed by your partner and you, indicating that you have made a significant contribution to the work submitted. The assignment is designed to help you develop problem-solving skills and obtain some progressive feedback. The benefit to you from doing the assignment is therefore much more important than the marks per se. There is little point in just copying the work of others. We will NOT accept an assignment that is simply copied. Copying the work of another person without acknowledgment is plagiarism and contrary to University policies on Academic Honesty in Coursework (see http://sydney.edu.au/policies/showdoc.aspx?recnum=PD0212/254&RendNum=0)

Practical Exam
These tests consist of a number of questions, similar to the exercises in prac sessions. Although you will work with a partner in the prac sessions, you must work on your own during the progress test. You will need to be able to write, compile and run simple codes to answer the questions in the tests.

Final Examination
These tests consist of a number of questions, similar to the exercises in prac sessions. Although you will work with a partner in the prac sessions, you must work on your own during the progress test and practical exam. You will need to be able to write, compile and run simple codes to answer the questions in the tests.

7.2 Assessment Grading
Final grades in this unit are awarded at levels of HD (High Distinction), D (Distinction), CR (Credit), P (Pass) and F (Fail) as defined by Academic Board Resolutions: Assessment and Examination of Coursework (see http://www.usyd.edu.au/ab/policies/Assess_Exam_Coursework.pdf). Distributions of grades in units offered by Schools in the Faculty of Science are governed by a policy based on 'norm-referencing' that defines the proportions of each grade awarded among student who pass. For Junior units of study, acceptable ranges of grades are:

<table>
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<th>Merit Grades</th>
<th>%HD</th>
<th>%HD + D</th>
<th>%HD + D + CR</th>
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Weekly Practical Sessions

<table>
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<th>Weekly Practical Sessions</th>
<th>10</th>
<th>Weekly</th>
<th>1, 2, 3, 4, 5, 6, 7</th>
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<td>Assignment</td>
<td>20</td>
<td>Week 10 Monday, 08 October 2012</td>
<td>1, 2, 4</td>
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<tr>
<td>Practical Exam</td>
<td>25</td>
<td>Week 13 (week starting Sunday, 28 October 2012)</td>
<td>1, 2, 4</td>
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<tr>
<td>Final Examination</td>
<td>45</td>
<td>Exam Period</td>
<td>1, 2, 7</td>
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</table>
The final mark for each unit is calculated by adding all the individual assessment marks with the appropriate weightings and then scaling to match University guidelines. This final scaling isn’t normally very great, but it does mean that you can’t simply add all your individual marks and get your final mark. The result of all this is a higher percentage of HDs and Ds in the Advanced unit (as you might expect), however the scaling also ensures there are HDs and Ds awarded in the other units of study.

8 Learning and Teaching Policies

Academic Dishonesty/Plagiarism

We will NOT accept assessments that are simply copied. Copying the work of another person without acknowledgment is plagiarism and contrary to University policies on Academic Dishonesty and Plagiarism [http://sydney.edu.au/policies/showdoc.aspx?recnum=PDOC2012/254&RendNum=0](http://sydney.edu.au/policies/showdoc.aspx?recnum=PDOC2012/254&RendNum=0)

Academic Dishonesty means seeking to obtain or obtaining academic advantage (for example, in assessments) by dishonest or unfair means or knowingly assisting another student to do so. Academic Dishonesty includes, but is not limited to:

(a) recycling – that is, the resubmission for assessment of work that is the same, or substantially the same, as Work previously submitted for assessment in the same or in a different unit of study (except in the case of legitimate resubmission with the approval of the examiner for purposes of improvement);

(b) fabrication of data;

(c) the engagement of another person to complete or contribute to an assessment or examination in place of the student, whether for payment or otherwise or accepting such an engagement from another student;

(d) communication, whether by speaking or some other means, to other candidates during an examination;

(e) bringing into an examination forbidden material such as textbooks, notes, calculators or computers;

(f) attempting to read other student’s work during an examination;

(g) writing an examination or test paper, or consulting with another person about the examination or test, outside the confines of the examination room without permission;

(h) copying from other students during examinations;

(i) Inappropriate use of electronic devices to access information during examinations.

Plagiarism means presenting another person’s work as one’s own work by presenting, copying or reproducing it without acknowledgement of the source. Plagiarism is a form of Academic Dishonesty, but is treated separately. Plagiarism includes presenting work for assessment, publication, or otherwise, that includes:

(a) phrases, clauses, sentences, paragraphs or longer extracts from published or unpublished work (including from the Internet) without acknowledgement of the source; or
Consideration of factors affecting your study

If your academic performance in a Science Faculty unit of study is adversely affected by illness or some other serious event, such as an accident, you should notify the Faculty of Science Student Information Office (level 2 of the Carslaw building) within 7 days after the period for which consideration is sought, by completing an Application for Special Consideration with accompanying documentation. This is especially important if you miss an examination.

If you have another reason for the Science Faculty to take account of your circumstances - religious commitments, legal commitments (e.g. Jury duty), elite sporting or cultural commitments (representing the University, state or country), or Australian Defence Force commitments (e.g. Army Reserve) - you should notify the Faculty of Science Student Information Office (level 2 of the Carslaw building) at least 7 days BEFORE the period for which consideration is sought, by completing an Application for Special Arrangements with accompanying documentation.

These two forms of Consideration should cover most allowable circumstances. However, if you have another reason for requiring the School of Physics to take account of your circumstances, you should notify the School of Physics Student Services Office immediately.

You should not submit an application of any type if

- there is no assessment associated with a missed class, or
- you have a reasonable opportunity to make up any work you missed.

If, for example, you miss an assignment, an application for appropriate Consideration is required to allow late submission, but we do expect the assignment to be submitted. Sometimes catching up may be impossible, in which case we will consider a pro-rata adjustment of your marks on the basis of an application for Consideration.

Special Consideration or Special Arrangements

To submit an application for Special Consideration or Special Arrangements you should:

1. Obtain the appropriate Application pack from the Student Information Office of the Faculty of Science, the Faculty website at http://sydney.edu.au/cstudent/ug/forms.shtml, or the Physics Student Services Office.
2. Complete the forms and obtain whatever original documentary evidence is appropriate. Note especially that the Professional Practitioner’s Certificate is essential for Special Consideration on grounds of serious illness - Medical Certificates will NOT be accepted.
3. Take the original copy of all forms and documents, plus sufficient copies for each unit of study affected and yourself, to the Faculty of Science Student Information Office (NOT any other Faculty Office if you are seeking Consideration in a unit taught by Physics). They will sign/stamp both the original application form and the copies. In the case of Physics units, one copy of the documentation must then be submitted to the Physics Student Services Office. Keep one copy yourself. A formal decision on your application will be sent to your university email address within 14 days.

Further details on University policy regarding Considerations can be found in policy documents entitled Assessment and Examination at the University Policy web site (http://sydney.edu.au/policy/).

Students unsure what type of Consideration is appropriate, or unhappy with a Consideration decision, should consult the Physics Student Services Office.

UNIVERSITY POLICIES
Academic Policies relevant to student assessment, progression and coursework:

- **Academic Honesty in Coursework.** All students must submit a cover sheet for all assessment work that declares that the work is original and not plagiarised from the work of others. The University regards plagiarism as a form of academic misconduct, and has very strict rules that all students must adhere to. For information see the document defining academic honesty and plagiarism [http://sydney.edu.au/ab/policies/Academic_Honesty_Cwk.pdf](http://sydney.edu.au/ab/policies/Academic_Honesty_Cwk.pdf)

- **Coursework assessment and examination policy.** The faculty policy is to use standards based assessment for units where grades are returned and criteria based assessment for Pass / Fail only units. Norm referenced assessment will only be used in exceptional circumstances and its use will need to be justified to the Undergraduate Studies Committee. Special consideration for illness or misadventure may be considered when an assessment component is severely affected. This policy gives the details of the information that is required to be submitted along with the appropriate procedures and forms (see link below).

- **Special Arrangements for Examination and Assessment.** In exceptional circumstances alternate arrangements for exams or assessment can be made. However concessions for outside work arrangements, holidays and travel, sporting and entertainment events will not normally be given. Start by going to the Faculty of Science Webpage, and downloading the ‘Special Consideration’ pack [http://sydney.edu.au/science/cstudent/ug/forms.shtml#special_consideration](http://sydney.edu.au/science/cstudent/ug/forms.shtml#special_consideration)

- **Student Appeals against Academic Decisions.** Students have the right to appeal any academic decision made by a school or the faculty. The appeal must follow the appropriate procedure so that a fair hearing is obtained.