# Course Outline

## MATH1081 Discrete Mathematics

School of Mathematics and Statistics

Faculty of Science

Term 3, 2021

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# Staff

| Position | Name | Email | Room* |
|---|---|---|---|
| Course Authority | Associate Prof Jonathan Kress | j.kress@unsw.edu.au | RC-3073 |
| Lecturers | Dr Daniel Mansfield | daniel.mansfield@unsw.edu.au | RC-4070 |
| Weekly Numbas<br>Lab Tests<br>Assignment | Dr Sean Gardiner | sean.gardiner@unsw.edu.au | RC-5108 |

*Note that the Red-Centre is closed at the time of production of this course outline and might remained closed throughout the term. Staff consultation will take place online and begin in Week 2. For details see Moodle.

# 1. Administrative matters

## Contacting the Student Services Office

Please visit the School of Mathematics and Statistics website for a wide range of information on School Policies, Forms and Help for Students by visiting the "**Student Services"** page.

For information on Courses, please go to "**Current Student**", "Undergraduate and/or Postgraduate" "**Courses Homepage**" for information on all **course offerings.**

The "Student Notice Board" can be located by going to the "Current Students" page; Notices are posted regularly for your information here. Please familiarise yourself with the information found in these locations. The School web page is found: http://www.maths.unsw.edu.au

If you cannot find the answer to your queries on the web pages you are welcome to contact the Student Services Office directly. The First Year Advisor in the Student Services Office is Ms Hilda Cahya. All administrative enquiries concerning first year Mathematics courses should be sent to H Cahya, either:

- By email to ug.mathsstats@unsw.edu.au
- By phone: 9385 7011 (leave message and contact phone number for call to be returned).
- Or in person to the Red Centre building, level 3, room 3072. NB: There is no contact at this office without prior appointment, please email while working remotely.

Change of tutorials, due to timetable clashes or work commitments, advice on course selection and other administrative matters are handled in the Student Services Office. Constructive comments on course improvement may also be emailed to the Director of First Year Mathematics, A/Prof Jonathan Kress. Should we need to contact you, we will use your official UNSW email address of

zstudentno@student.unsw.edu.au

in the first instance. **It is your responsibility to regularly check your university email account. Please state your student number in all emails to the Student Services Office.**

# 2. Course information

**Units of credit:** 6

**Assumed knowledge:** The assumed knowledge for this course is equivalent of a combined mark of at least 100 in the HSC Mathematics and HSC Mathematics Extension 1.

**Co-requisite:** The formal co-requisite is MATH1131 or MATH1141 or MATH1151. (You must either be taking one of these courses at the same time or have passed one already.)

**Teaching times and locations: see the link on the Handbook web page:**

Timetable for course MATH1081: http://timetable.unsw.edu.au/2021/MATH1081.html#S3

**Offered in:** Terms 1, 2 & 3

The subject matter of this course is very different from “high school mathematics” and success at high school is no guarantee of success in Discrete Mathematics. In MATH1081 emphasis is placed on reasoned argument and clarity of exposition as well as algebraic and computational skills.

## Course summary

MATH1081 will enhance your research, inquiry and analytical thinking abilities as it will provide you with the mathematical language and mathematical techniques to unravel many seemingly unrelated problems. The course will engage you in independent and reflective learning through your independent mastery of a wide range of tutorial problems. The mathematical problem-solving skills that you will develop are generic problem solving skills, based on logical arguments and mathematical language that can be applied in multidisciplinary work. You will be encouraged to develop your communication skills through active participation in tutorials, and by writing clear, logical arguments when solving problems.

## Course aims

The aim of MATH1081 is that by the time you finish the course you should understand the concepts and techniques covered by the syllabus and have developed skills in applying these concepts and techniques to the solution of appropriate problems. Successful completion of the course will give you a good foundation for understanding many problems that arise many applications and particularly those in computer science.

## Course learning outcomes (CLO)

At the successful completion of this course you (the student) should be able to:

1. State definitions and theorems in the syllabus and apply them to specific examples.
2. Apply the concepts and techniques of the syllabus to solve appropriate problems.
3. Communicate mathematical ideas effectively using correct terminology.
4. Use technology as an aid to communicate mathematical ideas.
5. Recognise and create valid mathematical arguments.

# 3. Learning and teaching activities

## Lecture and Tutorial Schedule

Please note that Lectures commence in week 1 and run to week 10 according to your myUNSW timetable. Lectures may continue into week 11 according to need.

| Activity | Monday | Tuesday | Wednesday | Thursday | Friday |
|---|---|---|---|---|---|
| **Lecture** Online | | 4 - 6pm (Wk 1-5,7-10) | 2 - 3pm (Wk 1-5,7-10) | | 1 - 3pm (Wk 1-5, 7-10) |
| **Other** (assessment activity) | Lab Tests will be at a variety of times. See Moodle one week in advance. | | | | |
| **Tutorial** | Refer to http://timetable.unsw.edu.au/2021/MATH1081.html#S3 | | | | |

Students must enroll into a pair of tutorials. The "Other" activity is for assessments only. Tutorials are compulsory. Web lectures are provided through the Moodle course page as a link to the Lecture videos.

There are 5 hours of lectures per week except in week 6. Lectures commence in week 1 and run to week 10. Full details of the timetable are shown in your timetable in myUNSW and the online Handbook (link above).

The material presented is divided into five sections or topics. The approximate lecture numbers for each topic is shown below.

| **Topics** | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **Lectures** | 1 to 8 | 9 to 15 | 16 to 28 | 29 to 39 | 40 to 45 |

## Classroom Tutorials

Each student enrolled in MATH1081 has been assigned two tutorial time slots as shown in your timetable. Students can change their tutorials via myUNSW until the end of week 1. After that time, they can only change tutorials by contacting the Maths & Stats Student Services (see page 3) with evidence of a timetable clash or work commitments

Each student will have two tutorials per week with the same tutor, with tutorials in weeks 1 to 5 and 7 to 10. Attendance at tutorials is compulsory and the roll will be kept in tutorials.

In Term 3 the Classroom Tutorials will be online using Blackboard Collaborate. From Week 7, there may be some optional face-to-face activities, depending on conditions at the time. Details will be provided on Moodle.

## Weekly Numbas Lessons

In addition to the Classroom Tutorials, MATH1081 has a weekly Numbas lesson in the form of a short set of exercises. These are described below in the Assessment section.

## UNSW Moodle

The School of Mathematics and Statistics uses the Learning Management System called Moodle. To log into Moodle, use your zID and zPass at the following URL: http://moodle.telt.unsw.edu.au

Here you will find announcements, general information, notes, lecture slide, classroom tutorial and homework problems and links to Numbas lessons and assessments.

# 4. Assessment

## Assessment overview

In Term 3 2021 all assessments will be online.

The final mark will be made up as follows:

| Assessment task | Weight | CLOs |
|---|---|---|
| Numbas exercises<br>Weekly lessons: 10% for best 6 of 9;<br>Lab tests: 15% each for two tests | 40% | 1,2,5 |
| Assignment | 10% | 1,2,3,4,5 |
| End of term examination | 50% | 1,2,3,5 |

To pass this course a student needs final overall mark of at least 50%. There is no requirement to obtain a pass in any one assessment task.

Each type of assessment is described below in detail.

Note:

- You will be able to view your final exam timetable on myUNSW. Details of when this timetable will be released is available on the university website.

  https://student.unsw.edu.au/dates-and-timetables

- It is very important that you understand the University's rules for the conduct of Examinations and the penalties for **Academic Misconduct Guide**. This information can be accessed through myUNSW at:

  https://student.unsw.edu.au/conduct

- In recent years there have been cases where severe penalties have been imposed for misconduct in relation to tests and exams in Maths courses.

- UNSW assesses students under a standards based assessment policy. For how this policy is applied within the School of Mathematics and Statistics, please visit the web site:

  https://www.maths.unsw.edu.au/currentstudents/assessment-policies

- For information on how the School implements special consideration policies for assessments during the term and the final examination, refer to the School's website:

  https://www.maths.unsw.edu.au/currentstudents/special-consideration-illness-misadventure

## Weekly Numbas Lessons

Each week there will be a Numbas Lesson to complete on Moodle. These lessons may cover material either before or after it is covered in lectures. Instructions will be provided on Moodle. The deadline for each week's exercises will be 5pm each Monday throughout the term. Your best 6 of the 9 weeks will count towards your final mark.

These Numbas Lessons will cover basic skills. The material covered in each can include upcoming topics as preparation to help you get the most out of lectures and tutorials, as well as material already covered in the lectures and tutorials to help you prepare for the lab tests.

You are encouraged to work on these exercises in groups with other students, but you must only enter answers to

your questions that you have worked out for yourself.

The weekly Numbas Lessons allow you to check your answers as you go so you should aim to achieve a near perfect score. You can also repeat these as many times as you like and you may find this useful for practice and revision. After each weekly deadline, a revision version will be available but will not count towards your final mark.

## Lab Tests

As well as completing the weekly online component of the Numbas Lessons, you will take two Lab Tests based on a similar set of questions. Note that although these will not be conducted in the lab this term, they are will still be referred to as Lab Tests. The Lab Test questions will be provided on Moodle for practice at least one week before the beginning of the tests. These tests will be conducted online in week 4 for the first test and week 10 for the second test. The times that these tests will be available will be announced on Moodle.

## Assignment

The assignment is designed to help you construct logically correct mathematical arguments and communicate mathematical ideas. Details of the assignment, including assessment criteria will be provided on Moodle. The assignment will be released by Monday of week 5. A draft version of your answers will be due by 5pm on Tuesday of week 7. You will then review the work of one peer and provide feedback by 5pm on Tuesday of week 8. Your feedback will be graded by a tutor and this will contribute one third of your assignment mark. You must then submit a final version of your assignment by 5pm Tuesday of week 10. Which will be graded and contribute two thirds of your assignment mark. A penalty of 5% (ie one 0.5% of your overall final mark) will be deducted for each day late, up to a maximum of 5 days late, for any of the 3 stages. See Moodle for more details.

## End of Term Examination

In Term 3 2021 the End of Term Examination will be conducted online using Maple TA. The time of the final examination will be available on myUNSW when the final exam timetable is released.

The end of term exam covers material from the whole syllabus. The best guide to the style and level of difficulty is the past exam papers. The course pack contains a book of past exam papers with worked solutions and additional past exams will be posted on Moodle. Examination questions are, by their nature, different from short test questions. They may test a greater depth of understanding. The questions will be longer, and sections of the course not covered in other assessments will be examined.

This term's exam will be closest in format to the 2021 Term 1 and 2 and 2020 exams. The 2019 exam papers are also of a similar length. Exams prior to 2019 are good for practice but had 4 questions rather 3 questions. Since 2019, students have more time during the 2 hour exam to answer each question. More specific information on the format will be provided on Moodle close to the end of Term.

The assessment tasks during the term allow repeated attempts over an extended period and resources are available to students attempting these assessments. As a result, students should be aiming for a high mark in the pre-exam assessment and this indicates significant progress towards achieving the learning outcomes of this course. The exam is time limited and has more complex questions. Therefore, a high mark in the pre-exam assessment is not always an accurate indication of the final course mark.

# 5. Expectations of students

## School Policies

The School of Mathematics and Statistics has adopted a number of policies relating to enrolment, attendance, assessment, plagiarism, cheating, special consideration etc. These are in addition to the Policies of The University of New South Wales. Individual courses may also adopt other policies in addition to or replacing some of the School ones. These will be clearly notified in the Course Initial Handout and on the Course Home Pages

on the Maths Stats web site.

Students in courses run by the School of Mathematics and Statistics should be aware of the School and Course policies by reading the appropriate pages on the Maths Stats web site starting at:

http://www.maths.unsw.edu.au/currentstudents/assessment-policies

The School of Mathematics and Statistics will assume that all its students have read and understood the School policies on the above pages and any individual course policies on the Course Initial Handout and Course Home Page. Lack of knowledge about a policy will not be an excuse for failing to follow the procedure in it.

## Academic integrity, referencing and plagiarism

**Academic integrity** is fundamental to success at university. Academic integrity can be defined as a commitment to six fundamental values in academic pursuits**:** honesty, trust, fairness, respect, responsibility and courage.[1] At UNSW, this means that your work must be your own, and others' ideas should be appropriately acknowledged. If you don't follow these rules, plagiarism may be detected in your work.

Further information about academic integrity and **plagiarism** can be located at:

- The *Current Students* site https://student.unsw.edu.au/plagiarism**,** and
- The *ELISE* training site http://subjectguides.library.unsw.edu.au/elise/presenting

The *Conduct and Integrity Unit* provides further resources to assist you to understand your conduct obligations as a student: https://student.unsw.edu.au/conduct.

## University Statement on Plagiarism

This statement has been adapted from statements by the St James Ethics Centre, the University of Newcastle, and the University of Melbourne.

Plagiarism is the presentation of the thoughts or work of another as one's own. Examples include:

Direct duplication of the thoughts or work of another, including by copying work, or knowingly permitting it to be copied. This includes copying material, ideas or concepts from a book, article, report or other written document (whether published or unpublished), composition, artwork, design, drawing, circuitry, computer program or software, web site, Internet, other electronic resource, or another person's assignment without appropriate acknowledgement

- Paraphrasing another person's work with very minor changes keeping the meaning, form and/or progression of ideas of the original;
- Piecing together sections of the work of others into a new whole;
- Presenting an assessment item as independent work when it has been produced in whole or part in collusion with other people, for example, another student or a tutor; and,
- Claiming credit for a proportion a work contributed to a group assessment item that is greater than that actually contributed.
- Submitting an assessment item that has already been submitted for academic credit elsewhere may also be considered plagiarism.
- The inclusion of the thoughts or work of another with attribution appropriate to the academic discipline does not amount to plagiarism.

Students are reminded of their Rights and Responsibilities in respect of plagiarism, as set out in the University Undergraduate and Postgraduate Handbooks and are encouraged to seek advice from academic staff whenever necessary to ensure they avoid plagiarism in all its forms.

The Learning Centre website is the central University online resource for staff and student information

[1] International Center for Academic Integrity, 'The Fundamental Values of Academic Integrity', T. Fishman (ed), Clemson University, 2013.

on plagiarism and academic honesty. It can be located at: https://student.unsw.edu.au/plagiarism

The Learning Centre also provides substantial educational written materials, workshops, and tutorials to aid students, for example, in:

- Correct referencing practices;
- Paraphrasing, summarising, essay writing, and time management;
- Appropriate use of, and attribution for, a range of materials including text, images, formulae and concepts.
- Individual assistance is available on request from The Learning Centre.

Students are also reminded that careful time management is an important part of study and one of the identified causes of plagiarism is poor time management. Students should allow sufficient time for research, drafting, and the proper referencing of sources in preparing all assessment items.

## Detection of academic misconduct

The School of Mathematics and Statistics uses a variety of means to detect and investigate potential academic misconduct in assessments, including the use of data from University systems and websites.

# 6. Readings and resources

## Course Pack

Your course pack should contain the following two items:

- *Problem Sets Booklet*
- *Past Exam Papers and Solutions Booklet*

These items can also be downloaded from UNSW Moodle, but many students find the hardcopy more efficient for study.

*NB: The **Course Outline** will be provided through the Moodle site and / or School web site, containing:*

Information on administrative matters, lectures, tutorials, assessment, syllabus, lab tests, assignment, special consideration and additional assessment.

## Textbook

S.S. Epp, “Discrete Mathematics with Applications”, Fourth Edition, 2011 OR Second (or Third) Edition, PWS 1995.

J Franklin and A. Daoud, “Introduction to Proofs in Mathematics”, Prentice Hall, 1988 or “Proof in Mathematics: An Introduction”, Quakers Hill Press, 1995.

## Reference Books

Any book with “Discrete Mathematics” and many with “Finite Mathematics” in their title should help. Previous texts include K.H. Rosen “Discrete Mathematics and its Application” and K. Kalmanson, “An Introduction to Discrete Mathematics and its Applications”. A more advanced reference is “Discrete Mathematics” by K. Ross and C.R.B. Wright.

For interesting applications within Computer Science, try the three part classic – D.E.Knuth, “The Art of Computer Programming”.

# 7. Getting help outside tutorials

## Staff Consultations

From week 2 there will be a roster which shows for each hour of the week a list of names of members of staff who are available to help students in the first year mathematics courses, no appointment is necessary. This roster will be announced in the Moodle course page at the end of week 1 and can be located by visiting web page:

http://www.maths.unsw.edu.au/currentstudents/consultation-mathematics-staff

## Mathematics Drop-in Centre

The Maths Drop-in Centre provides free help to students with certain first and second year mathematics courses. All first year MATH courses are supported. The Maths Drop-in Centre operates online via Moodle. For opening times, week the Drop-in Centre Moodle page.

The Maths Drop-in Centre schedule will be available on the Schools website and Moodle page below by the start of week 1. Please note that no appointment is necessary, this is a drop-in arrangement to obtain one-on-one help from tutors

https://www.maths.unsw.edu.au/currentstudents/Mathematics-Drop-in-Centre

## Additional support for students

- The Current Students Gateway: https://student.unsw.edu.au/
- Academic Skills and Support: https://student.unsw.edu.au/academic-skills
- Student Wellbeing, Health and Safety: https://student.unsw.edu.au/wellbeing
- Equitable Learning Services: https://student.unsw.edu.au/els (formerly Disability Services Unit)
- UNSW IT Service Centre: https://www.it.unsw.edu.au/students/index.html

# 8. Applications for Special Consideration

If you are unable to complete an assessment on time or during the proscribed period due to illness or other reason beyond your control, you can apply for special consideration.

For all information on Special Consideration, including the circumstances that are covered or excluded and how to apply, see the Special Consideration web site:

https://student.unsw.edu.au/special-consideration

Please note that the application is not considered by the Course Authority, it is considered by a centralised team of staff at the Nucleus Student Hub.

The central team will advise you, by email to your UNSW student email, of the outcome of your application and the date of any supplementary assessment or extension as appropriate.

For final exams with special consideration granted, the Exams Unit will email the rescheduled "supplementary exam" date, time and location to your student zID email account directly. Please ensure you regularly check your student email account (zID account) for this information.

The supplementary exam period/dates can be found at this web site:

https://student.unsw.edu.au/exam-dates

Please ensure you are aware of these dates and that you are available during this time.

## Important Notes

If you believe your application for Special Consideration has not been processed, you should email **specialconsideration@unsw.edu.au** immediately for advice.

- If you suffer from a chronic or ongoing illness that has, or is likely to, put you at a serious disadvantage, then you should contact the Equitable Learning Services (formerly known as the Disability Support Services) who provide confidential support and advice. Their web site is: https://student.unsw.edu.au/els
- Equitable Learning Services (ELS) may determine that your condition requires special arrangements for assessment tasks. Once the School has been notified of these, we will make every effort to meet the arrangements specified by ELS.
- Additionally, if you have suffered significant misadventure that affects your ability to complete the course, please contact the Director of First Year, Associate Professor Jonathan Kress by email or in person for advice. The contact details are the Red Centre, level 3 room RC-3073 or by email to j.kress@unsw.edu.au

Professor A Coster
Head, School of Mathematics and Statistics

# 9. Syllabus

References are to the textbook by Epp, unless marked otherwise. F indicates the textbook by Franklin and Daoud and R indicates the book *Discrete Mathematics with Applications* by K.H. Rosen (6th edition). The UNSW Library has multiple copies of Rosen numbered P510/482A,B,C, etc.

The references shown in the righthand column are *not* intended to be a definition of what you will be expected to know. They are just intended as a guide to finding relevant material. Some parts of the course are not covered in the textbooks and some parts of the textbooks (even in sections mentioned in the references below) are not included in the course.

In the Reference column below, column A refers to Epp 3rd edition, and Rosen 2nd edition, while column B to Epp 4th edition and Rosen 6th edition.

Within sections of the course, the topics may not be covered in exactly the order in which they are listed below.

| Topic | References A | References B |
|---|---|---|
| **1: Sets and Functions** | | |
| Sets, subsets, power sets. Equality, cardinality | 5.1, 5.3 | 1.2, 6.1, 6.3 |
| Set operations: union, intersection, difference, Cartesian product. | 5.1 | 6.1 |
| Universal sets, complements. | 5.2 | 6.2 |
| Russell's paradox. | 5.4 | 6.4 |
| Functions. Domain, codomain and range. Arrow diagrams. | 7.1, 3.5 | 1.3, 7.1, 4.5 |
| Ceiling and floor functions. Images and inverse images of sets. Injective (one-to-one), surjective (onto) and bijective functions. | 7.3 | 7.2 |
| Composition of functions | 7.4 | 7.3 |
| Inverse functions. | 7.2 | 7.2 |
| Sequences, sums and products. Notation. | 4.1 | 5.1 |
| Change of variable in a sum. Telescoping sums | | |
| **2: Integers, Modular Arithmetic and Relations** | | |
| Prime numbers and divisibility | 3.1, 3.3 | 4.1, 4.3 |
| Fundamental Theorem of Arithmetic | 3.3 | 4.3 |
| Euclidean Algorithm | 3.8 | 4.8 |

| | | |
|---|---|---|
| Modular Arithmetic | 3.4 | 4.4, 8.4 |
| Solving Linear Congruences | R2.5 | R3.7 |
| General Relations | 10.1 | 8.1 |
| Reflexivity, symmetry and transitivity | 10.2 | 8.2 |
| Equivalence Relations | 10.3 | 8.3 |
| Partially ordered sets and Hasse diagrams | 10.5 | 8.5 |

**3: Logic and Proofs**

| | | |
|---|---|---|
| Proof versus intuition. Direct proof. | F1 | F1 |
| Propositions, connectives, compound propositions. | 1.1 | 2.1 |
| Truth tables. Tautology, contingency, logical equivalence. | 1.1 | 2.1 |
| Implication, converse, inverse, biconditional. | 1.2 | 2.2 |
| Rules of inference | 1.3 | 2.3 |
| Contrapositive, indirect proof, proof by contradiction | 1.2, 3.6, F6,3.7 | 2.2,4.6,4.7, F6 |
| Quantifiers | 2.1 | 3.1 |
| Proof of universal statements, exhaustion, proof by cases. | 2.1, F2, F3 | 3.1, F2, F3 |
| Proof of existential statements. Constructive and non-constructive proofs. Counterexamples. | 2.1, 3.1, F4, F6 | 3.1,4.1,F4,F6 |
| Negation of quantified statements. | 2.1 | 3.2 |
| Statements with multiple quantifiers. | 2.1 | 3.2 |
| Common mistakes in reasoning. Converse and inverse fallacies. Begging the question, tacit assumption, etc. | 2.3, 3.1 | 3.3, 3.4, 4.1 |
| Mathematical induction | 4.2-4.4, F8 | 5.2-5.4, F8 |

Note: In addition to the sections of Epp mentioned above, sections 4.2–4.5 and 4.7 (3.2–3.5,3.7 for edition 3) provide many useful worked examples of constructing proofs in elementary number theory.

**4: Enumeration and Probability**

| | | |
|---|---|---|
| Counting and Probability | 6.1 | 9.1 |
| Multiplication Rule | 6.2 | 9.2 |
| Addition Rule | 6.3 | 9.3 |
| Principle of Inclusion-Exclusion | 6.3 | 9.3 |
| Pigeonhole Principle | 7.3 | 9.4 |
| Permutations and Combinations | 6.4, 6.5 | 9.5, 9.6 |
| Binomial and Multinomial Theorem | 6.7, R4.6 | 9.7, R5.4 |
| Discrete Probability | R4.4, 6.1 | R6.1, 9.1 |
| Recurrence Relations | 8.2, 8.3 | 5.6, 5.7, 5.8 |
| Recursively Defined Sets and Functions | 8.1 | 5.9 |

**5: Graphs**

| | | |
|---|---|---|
| Basic terminology. simple graphs, $K_n$.Directed graphs, subgraphs, complementary graphs. | 11.1 | 10.1 |
| Degree, the Handshaking Theorem (Epp Theorem 10.1.1 (11.1.1 in ed. 3)) | 11.1 | 10.1 |
| Bipartite graphs, $K_{m,n}$. | 11.1 | 10.1 |
| Adjacency and incidence matrices. | 11.3 | 10.3 |
| Isomorphism, isomorphism invariants. | 11.4 | 10.4 |
| Walks, paths and circuits. Euler and Hamilton paths. Connected graphs, connected components. | 11.2 | 10.2 |
| Planar graphs. Euler's formula. Dual graphs. Necessary conditions for planarity. Kuratowski's Theorem. | R7.7 | R9.7 |
| Trees, spanning trees. | 11.5, 11.6 | 10.5, 10.7 |
| Weighted graphs. Minimal spanning trees. Kruskal and Dijkstra algorithms. | 11.6 | 10.6, 10.7 |