PHYS242

Big Ideas in Science

S2 Day 2018

Dept of Physics and Astronomy

Contents

General Information

Unit convenor and teaching staff
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Credit points
3

Prerequisites
12cp at 100 level or above

Corequisites

Co-badged status

Unit description
What is science? How have influential thinkers such as Einstein and Darwin shaped our view of the world? This unit presents a big picture of science as a great triumph of the human mind and imagination. Scientists have given us a powerful framework for understanding our world from the microscopic scale to the scale of the whole universe. This unit gives students insight into some of the big ideas in science; from cosmology, and the universe through the mysteries of quantum phenomena; from atoms to the evolution of life itself. By exploring the big ideas in science, students gain an understanding of the power and dynamism of scientific knowledge. This unit provides intellectual enrichment for both science and non-science students.

Important Academic Dates

Information about important academic dates including deadlines for withdrawing from units are available at https://www.mq.edu.au/study/calendar-of-dates

Learning Outcomes

On successful completion of this unit, you will be able to:

Students should gain a broad perspective of some of the big ideas in science.
Students should understand and be able to comment on the historical development of scientific ideas and the idea of science itself.
Students should demonstrate a capacity to distinguish between what are still open scientific questions and what are settled questions, and be able to formulate extended arguments to defend the distinction.
Students should gain and be able to communicate a significant and informed understanding of the science behind topical issues such as climate change
Students will develop skills in critically analysing issues in science and will be able to communicate these to a general audience.

Assessment Tasks

Name	Weighting	Hurdle	Due
Source Evaluation Assignment	20%	No	Friday 17 August
Essays	35%	No	14 Sept
Debates on Big Science Topics	30%	No	Weeks 11/12
On-line FlipGrid Video Forum	15%	No	Each week

Source Evaluation Assignment

Due: **Friday 17 August**
Weighting: **20%**

In this assignment, you will be asked to evaluate some web sites as to their accuracy, motive, usefulness etc. When so much information is freely available on the web, it is important to critically assess its accuracy/value, particularly because anyone can publish anything on the web, yet what is published often has hidden biases or agendas, or may contain misconceptions, errors of fact both intentional and unintentional. This assignment will get you to explicitly evaluate web sites, though you should always evaluate a web site before considering it to be a useful resource for information.

This assignment should be submitted in hard copy with coversheet to the Science and Engineering Student Centre in E7B (ground floor); AND electronically via ilearn (to allow plagiarism checking through Turnitin).

On successful completion you will be able to:

- Students should demonstrate a capacity to distinguish between what are still open scientific questions and what are settled questions, and be able to formulate extended arguments to defend the distinction.
- Students should gain and be able to communicate a significant and informed understanding of the science behind topical issues such as climate change

Essays

Due: **14 Sept**
Weighting: **35%**

One essay "**Letters to the Past"**, will be set during session 2, worth 35%. Each student will be assigned a prominent inventor e.g. Fritz Haber, one of the inventors of the process to make industrial quantities of ammonia for fertilizer, and the essay will take the form of a letter that the student would send back in time, to the inventor, outlining the science of their invention and the technological and social ramifications that their invention has produced. The text of the essay has to be written in a form which would be understandable to the inventor in their era, i.e. jargon free.

Please include a bibliography (not included in any word- or page-limit), listing any relevant print- or Web-based resources from which you gathered your information. We are flexible with regard to format, as long as your citation references are clear and accurate. In order to satisfy the Policy on Plagiarism, it is important for you to use quotation marks ("...") to designate text that you have directly extracted and clearly acknowledge its bibliographic source. Plagiarism attracts severe penalties.

Essays will be submitted in hard copy with coversheet to the Science and Engineering Student Centre in E7B (ground floor); AND electronically via ilearn (to allow plagiarism checking through

Turnitin).

For guidance on writing essays including details on how to reference sources (and avoid plagiarism) please see this web site:

http://www.students.mq.edu.au/support/learning_skills/undergraduate/academic_skills_quickguides/

If you feel you need extra help with writing, see the Undergraduate Learning Skills Program:

http://www.students.mq.edu.au/support/learning_skills/undergraduate/

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Debates on Big Science Topics

Due: **Weeks 11/12**
Weighting: **30%**

Students will form small **debating teams**. In class debates will discuss the pros and cons of pre-set Big Science topics. This will help develop an important generic and critical thinking skills as well as give each student an opportunity to talk about a topic in science that they have researched.

On successful completion you will be able to:

- Students will develop skills in critically analysing issues in science and will be able to communicate these to a general audience.

On-line FlipGrid Video Forum

Due: **Each week**
Weighting: **15%**

Students are expected to participate in the on-line video discussion forums as an important part of engagement with this unit.

Each week where there will be an on-line question/video posted on the FlipGrid Forum for the class. Students have the opportunity to give a significant comment/view/reply to this question via a 90 second video.

The forum participation assessment will be given in three week chunks. Marks will be given for each student's **significant participation** over the three week chunk.

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Delivery and Resources

Classes

Lectures are on Fridays from noon to 2pm, 9 Wallys Wlk - 102 Theatrette. Attendance requirements: students are expected to participate in at least 80% of the lectures.

Tutorials are on Fridays at 2pm (14 Eastern Rd - 188 Tutorial Rm); and Fridays at 3pm (11 Wallys Wlk - 180 Tutorial Rm) and 4pm (11 Wallys Wlk - 180 Tutorial Rm). There will **not** be a tutorial each week.

Prizes

The Arthur Pryor Prize is awarded for excellence in this unit - worth extra effort!

Arthur Pryor was a brilliant student of Physics and Electrical Engineering. His career took him to the UK, New Zealand and back to Australia. He made major research contributions in under-water acoustics, neutron and thermal physics. He co-authored “Thermal Vibrations in Crystallography” and shared the 1964 Syme Prize, with AINSE co-workers, awarded for the best science contribution in any discipline in Australia. He taught PHYS242 in its beginnings in 1985 through to 1995.

Required and Recommended Texts and/or Materials

Required Text

Bill Bryson, A Short History of Nearly Everything, Black Swan (Random House).

Note a list of known errata for the text can be found on the unit iLearn page.

Further required reading for specific lecture topics will be available for download from ilearn.

Recommended Readings

Physics for Future Presidents, or Physics and Technology for Future Presidents, both books by R A Muller, Norton.

Galileo's Finger: The Ten Great Ideas of Science, Peter Atkins, Oxford University Press, 2004.

Technology Used and Required

This unit has an iLearn page at: https://ilearn.mq.edu.au/

Since 2015 we are introducing interactive elements into the lectures - bring your tablet, laptop or smartphone to lectures and tutorials to participate in live activities.

Teaching and Learning Strategy

This unit is taught through a mix of lecture/workshop activities and tutorials (tutorial classes are not scheduled each week, see unit schedule below).

We will have activities to encourage class discussion during lectures and tutorials - please come to these prepared to engage with your lecturers and class mates.

The textbook provides an interesting narrative account of science with emphasis on the people involved in scientific discovery as well as the evolution of the ideas themselves. The lectures will build on this background reading with an emphasis on gaining an understanding of important scientific concepts. In-class discussions will explore the foundations of our scientific understanding including confronting challenges to accepted scientific wisdom. Students will have assigned readings (mostly from the Bryson textbook) which should be completed prior to each class.

Specific tutorials will be provided for selected topics covered in the lectures as well as tutorials to aid in preparation for assessment as required. Online Video Discussion Forums will run continuously through the semester. This will give all students an open ended opportunity to discuss that week's topic with their peers and lecturers and show evidence that they have completed the required readings and engaged more deeply with that week's topic.

Students will also be able to explore selected topics in greater depth through the "Letters to the Past" essay and source evaluation as well as through engaging in in-class debates on Big Ideas topics to their peers. Unlike most other units with a PHYS prefix, this unit does not require a mathematical background, and is more conceptual than mathematical in nature.

Unit Schedule

Week	Topic	Lecturer	Bryson	Tutorials

1	**Planet Earth and Deep Time:** This lecture will explore the first two Big Ideas: That the Earth is billions of years old, not thousands, and that our planet has largely been shaped by gradual rather than catastrophic processes. We will make our first steps away from the time and length scales our every-day experience, a process that will be a subtext throughout this unit.	Jason Twamley	Chapters 5, 12	Tutorial: Sources & Essays (JT@2, 3pm, GKB@4pm)
2	**Climate Change:** We live on a finite planet: As a species, through our actions we can have an impact on the planet as a whole. This is most evident in Anthropogenic Climate Change, which has been described as one of the hottest issues of our time. We may all have to modify our lifestyles both to reduce climate change and because of the consequences of climate change. Climate change has emerged as a major political issue, yet do you really understand climate science sufficiently well to be making informed electoral choices? We will explore the basic science which results in the mean global temperatures we see today, and why these temperatures are rising, and what the effects of the temperature rise may be.	Jason Twamley	17, 27	Climate Change Tutorial: can you answer the critics? (JT@2,3pm, GKB@4pm)
3	**Cosmology:** Although we may believe we are masters over our domain, Planet Earth, and that we are the Centre of the Universe, actually, we live on a small pale blue dot orbiting an nondescript star that is just one of billions in an unremarkable galaxy in an incomprehensibly vast Universe. This lecture will cover the story of our universe from the Big Bang to the formation of the solar system and the ultimate fate of the universe.	Jason Twamley	1,2,3	No tutorial
3	Source Evaluation Assignment Due	JT and GKB		
4	**Relativity:** Einstein showed us that no one is a privileged observer of the world, and that the laws of physics should be the same for all regardless of their relative motion. This simple idea led Einstein to some startling mind (and space) bending conclusions where our everyday common sense is completely wrong. We will explore Einstein's theories of Special Relativity and General Relativity at a conceptual level including curved space time and the mysteries of black holes.	Gavin Brennen	8	No tutorial
5	**The Quantum World:** As Einstein was overturning our understanding of space and time, the founders of Quantum Mechanics upended the concepts of determinism and the clockwork universe in the effort to describe nature at the very small scale. Quantum mechanics today is by far our most accurate and successful physical theory, and yet its core tenets seem to conflict with our common sense and experience even more profoundly than relativity. Why must we accept that particles can exist in multiple locations at once, why can familiar quantities like position and momentum not coexist, what is really the role of an observer in an experiment, and how does our macroscopic classical world emerge from such an exotic microscopic foundation?	Gavin Brennen	9, 11	No tutorial

6	**Evolution:** Historically, one of the most shocking Big Ideas in Science was Darwin's publication of On the Origin of Species in 1859 where he argued convincingly for the first time that all life on Earth has descended from a common ancestor. The objective of this topic is to explore the question "Where did living things (including ourselves) come from?" We will trace the history of our attempts to answer this question beginning with ideas of the spontaneous generation of life and culminating in Darwin's theory of Evolution, Mendelian inheritance and DNA. We will also explore some of the issues for society including GM foods, eugenics, cloning, pharmacogenetics and the human genome.	Michael Steel	19, 25, Optional: 21, 22, 2 7,9	Evolution Tutorial: Can you answer the critics? (MS@2pm, GKB @3,4pm)
7	**Particles:** From the vast scale of the Universe, we now turn inwards to the microscopic realm: One of the most important and oldest ideas in Science is that the physical world is composed of particles (atoms and sub-atomic particles). While atoms are almost self-evident nowadays, the development of atomic theory is a fascinating journey through the history of ideas. We will look at some of the important milestones on this journey, taking us up to the present day where scientists can control and study single atoms or groups of a few atoms.	Gavin Brennen	7,9	No tutorial
7	Letters to the Past Due	JT, GKB, MS, CP		
Break				
8	**Energy and Entropy:** Energy is neither created nor destroyed, it is just transformed from one form to another as a fundamental primary quantity that drives all physical processes. But energy is also something that we pay for at the petrol pump and we receive regular electricity bills. So what is Energy, and what is Entropy, and how are these fundamental concepts related? What is their connection to the arrow of time? Do you know how much energy is contained in a cupful of petrol, an AA battery or a meteor impact? We will explore energy in all its forms including energy generation through renewable and other technologies.	Gavin Brennen	13	Energy and Entropy Tutorial: The Energy Crisis
9	**Symmetry:** Symmetry pervades art, architecture and nature through to the deepest laws of physics. Indeed, many of the fundamental laws of nature arise from arguments based on symmetry. Are symmetry ideas then the basis for all our physical laws? We will explore the importance of symmetry as a powerful concept in science and the world.	Gavin Brennen	Readings will be provided	No tutorial
10	**Limits of Reason:** Is reality real or are we all living in a matrix? Does an objective reality exist independent of any observer? "If a tree falls in a forest and no one is there to hear it, does it make a noise?" is a philosophical thought experiment that raises questions regarding observation and knowledge of reality. With our brains, we simulate the external world as an internal model, based on sensory inputs that we receive. This means that there is no direct access to reality and our brain and the mind it creates is constrained to interpret the world in certain ways. In this lecture we will examine the neuroscience of thought processes and the way that the brain handles information. We will also look into the science of consciousness and explore the differences (or similarities?) between human and artificial intelligence.	Cormac Purcell	Readings will be provided	No tutorial

11	Class Debates	Cormac Purcell (Coordinator), JT, GKB, MS		Class Debates
12	Class Debates	Cormac Purcell (Coordinator), JT, GKB, MS		Class Debates
13	**2018 Nobel Prizes:** In the final lecture, we will look at the 2016 Nobel Prizes (which will only just have been announced).	JT, GKB, MS, CP	Readings will be provided	No tutorial

Learning and Teaching Activities

Lectures

Each week there will be one 2 hour lecture slot, each week devoted to one of the Big Ideas in Science.

Tutorials

Some lecture topics cover material that is very well suited to further in-class discussion and debate, and for those topics there will be specific discussion tutorials. Other tutorials related to the assessment will also be provided. See schedule for which weeks will have tutorials.

Discussion Forums

We will have a student video discussion forum each week to facilitate wider discussion of that week's topic.

Policies and Procedures

Macquarie University policies and procedures are accessible from Policy Central (https://staff.mq.edu.au/work/strategy-planning-and-governance/university-policies-and-procedures/policy-central). Students should be aware of the following policies in particular with regard to Learning and Teaching:

- Academic Appeals Policy
- Academic Integrity Policy
- Academic Progression Policy
- Assessment Policy
- Fitness to Practice Procedure
- Grade Appeal Policy
- Complaint Management Procedure for Students and Members of the Public

- Special Consideration Policy *(**Note:** The Special Consideration Policy is effective from 4 December 2017 and replaces the Disruption to Studies Policy.)*

Undergraduate students seeking more policy resources can visit the Student Policy Gateway (https://students.mq.edu.au/support/study/student-policy-gateway). It is your one-stop-shop for the key policies you need to know about throughout your undergraduate student journey.

If you would like to see all the policies relevant to Learning and Teaching visit Policy Central (https://staff.mq.edu.au/work/strategy-planning-and-governance/university-policies-and-procedures/policy-central).

Student Code of Conduct

Macquarie University students have a responsibility to be familiar with the Student Code of Conduct: https://students.mq.edu.au/study/getting-started/student-conduct

Results

Results shown in *iLearn*, or released directly by your Unit Convenor, are not confirmed as they are subject to final approval by the University. Once approved, final results will be sent to your student email address and will be made available in eStudent. For more information visit ask.mq.edu.au.

Student Support

Macquarie University provides a range of support services for students. For details, visit http://students.mq.edu.au/support/

Learning Skills

Learning Skills (mq.edu.au/learningskills) provides academic writing resources and study strategies to improve your marks and take control of your study.

- Workshops
- StudyWise
- Academic Integrity Module for Students
- Ask a Learning Adviser

Student Services and Support

Students with a disability are encouraged to contact the Disability Service who can provide appropriate help with any issues that arise during their studies.

Student Enquiries

For all student enquiries, visit Student Connect at ask.mq.edu.au

IT Help

For help with University computer systems and technology, visit http://www.mq.edu.au/about_us/offices_and_units/information_technology/help/.

When using the University's IT, you must adhere to the Acceptable Use of IT Resources Policy. The policy applies to all who connect to the MQ network including students.

Graduate Capabilities

Creative and Innovative

Our graduates will also be capable of creative thinking and of creating knowledge. They will be imaginative and open to experience and capable of innovation at work and in the community. We want them to be engaged in applying their critical, creative thinking.

This graduate capability is supported by:

Learning outcome

- Students will develop skills in critically analysing issues in science and will be able to communicate these to a general audience.

Assessment task

- Debates on Big Science Topics

Learning and teaching activity

- Some lecture topics cover material that is very well suited to further in-class discussion and debate, and for those topics there will be specific discussion tutorials. Other tutorials related to the assessment will also be provided. See schedule for which weeks will have tutorials.

Capable of Professional and Personal Judgement and Initiative

We want our graduates to have emotional intelligence and sound interpersonal skills and to demonstrate discernment and common sense in their professional and personal judgement. They will exercise initiative as needed. They will be capable of risk assessment, and be able to handle ambiguity and complexity, enabling them to be adaptable in diverse and changing environments.

This graduate capability is supported by:

Learning outcome

- Students should demonstrate a capacity to distinguish between what are still open scientific questions and what are settled questions, and be able to formulate extended arguments to defend the distinction.

Assessment tasks

- Source Evaluation Assignment
- On-line FlipGrid Video Forum

Learning and teaching activities

- Each week there will be one 2 hour lecture slot, each week devoted to one of the Big Ideas in Science.
- Some lecture topics cover material that is very well suited to further in-class discussion and debate, and for those topics there will be specific discussion tutorials. Other tutorials related to the assessment will also be provided. See schedule for which weeks will have tutorials.
- We will have a student video discussion forum each week to facilitate wider discussion of that week's topic.

Commitment to Continuous Learning

Our graduates will have enquiring minds and a literate curiosity which will lead them to pursue knowledge for its own sake. They will continue to pursue learning in their careers and as they participate in the world. They will be capable of reflecting on their experiences and relationships with others and the environment, learning from them, and growing - personally, professionally and socially.

This graduate capability is supported by:

Learning outcomes

- Students should gain a broad perspective of some of the big ideas in science.
- Students should understand and be able to comment on the historical development of scientific ideas and the idea of science itself.
- Students should demonstrate a capacity to distinguish between what are still open scientific questions and what are settled questions, and be able to formulate extended arguments to defend the distinction.
- Students should gain and be able to communicate a significant and informed understanding of the science behind topical issues such as climate change

Assessment tasks

- Source Evaluation Assignment
- On-line FlipGrid Video Forum

Learning and teaching activities

- Some lecture topics cover material that is very well suited to further in-class discussion and debate, and for those topics there will be specific discussion tutorials. Other tutorials related to the assessment will also be provided. See schedule for which weeks will have tutorials.
- We will have a student video discussion forum each week to facilitate wider discussion of

that week's topic.

Discipline Specific Knowledge and Skills

Our graduates will take with them the intellectual development, depth and breadth of knowledge, scholarly understanding, and specific subject content in their chosen fields to make them competent and confident in their subject or profession. They will be able to demonstrate, where relevant, professional technical competence and meet professional standards. They will be able to articulate the structure of knowledge of their discipline, be able to adapt discipline-specific knowledge to novel situations, and be able to contribute from their discipline to inter-disciplinary solutions to problems.

This graduate capability is supported by:

Learning outcomes

- Students should demonstrate a capacity to distinguish between what are still open scientific questions and what are settled questions, and be able to formulate extended arguments to defend the distinction.
- Students should gain and be able to communicate a significant and informed understanding of the science behind topical issues such as climate change
- Students will develop skills in critically analysing issues in science and will be able to communicate these to a general audience.

Assessment tasks

- Essays
- Debates on Big Science Topics

Learning and teaching activities

- Each week there will be one 2 hour lecture slot, each week devoted to one of the Big Ideas in Science.

Critical, Analytical and Integrative Thinking

We want our graduates to be capable of reasoning, questioning and analysing, and to integrate and synthesise learning and knowledge from a range of sources and environments; to be able to critique constraints, assumptions and limitations; to be able to think independently and systemically in relation to scholarly activity, in the workplace, and in the world. We want them to have a level of scientific and information technology literacy.

This graduate capability is supported by:

Learning outcomes

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scientific ideas and the idea of science itself.

- Students should demonstrate a capacity to distinguish between what are still open scientific questions and what are settled questions, and be able to formulate extended arguments to defend the distinction.
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Assessment tasks

- Source Evaluation Assignment
- Essays
- On-line FlipGrid Video Forum

Learning and teaching activities

- Some lecture topics cover material that is very well suited to further in-class discussion and debate, and for those topics there will be specific discussion tutorials. Other tutorials related to the assessment will also be provided. See schedule for which weeks will have tutorials.
- We will have a student video discussion forum each week to facilitate wider discussion of that week's topic.

Problem Solving and Research Capability

Our graduates should be capable of researching; of analysing, and interpreting and assessing data and information in various forms; of drawing connections across fields of knowledge; and they should be able to relate their knowledge to complex situations at work or in the world, in order to diagnose and solve problems. We want them to have the confidence to take the initiative in doing so, within an awareness of their own limitations.

This graduate capability is supported by:

Assessment tasks

- Source Evaluation Assignment
- Essays
- Debates on Big Science Topics

Effective Communication

We want to develop in our students the ability to communicate and convey their views in forms effective with different audiences. We want our graduates to take with them the capability to read, listen, question, gather and evaluate information resources in a variety of formats, assess,

write clearly, speak effectively, and to use visual communication and communication technologies as appropriate.

This graduate capability is supported by:

Learning outcome

- Students will develop skills in critically analysing issues in science and will be able to communicate these to a general audience.

Assessment tasks

- Source Evaluation Assignment
- Essays
- Debates on Big Science Topics
- On-line FlipGrid Video Forum

Learning and teaching activities

- Each week there will be one 2 hour lecture slot, each week devoted to one of the Big Ideas in Science.
- Some lecture topics cover material that is very well suited to further in-class discussion and debate, and for those topics there will be specific discussion tutorials. Other tutorials related to the assessment will also be provided. See schedule for which weeks will have tutorials.
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Engaged and Ethical Local and Global citizens

As local citizens our graduates will be aware of indigenous perspectives and of the nation's historical context. They will be engaged with the challenges of contemporary society and with knowledge and ideas. We want our graduates to have respect for diversity, to be open-minded, sensitive to others and inclusive, and to be open to other cultures and perspectives: they should have a level of cultural literacy. Our graduates should be aware of disadvantage and social justice, and be willing to participate to help create a wiser and better society.

This graduate capability is supported by:

Learning outcomes

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Assessment tasks

- Debates on Big Science Topics
- On-line FlipGrid Video Forum

Learning and teaching activities

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Socially and Environmentally Active and Responsible

We want our graduates to be aware of and have respect for self and others; to be able to work with others as a leader and a team player; to have a sense of connectedness with others and country; and to have a sense of mutual obligation. Our graduates should be informed and active participants in moving society towards sustainability.

This graduate capability is supported by:

Learning outcomes

- Students should demonstrate a capacity to distinguish between what are still open scientific questions and what are settled questions, and be able to formulate extended arguments to defend the distinction.
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- Students will develop skills in critically analysing issues in science and will be able to communicate these to a general audience.

Learning and teaching activities

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Changes from Previous Offering

Since 2015 we are working to encourage students to be more involved with this unit. We have introduced an assessed discussion forum which replaces weekly on-line quizzes. We have also

introduced more participation elements into the lectures including use of Socrative and discussion sessions. We hope you will enjoy the changes and look forward to getting to know you through the session.

In 2016 we have dropped the role of Forum Leaders. All the students are participating at the same level in the Forum. In order to better assess the quality of the comments, two random weeks will be picked for each student for an in-depth review of the quality of the posts. Also, in contrast to last year, Online Discussion Forums will run during all the semester, not only on weeks without a Tutorial.

In 2018 we have dropped the ilearn discussion forum and are trialing a video discussion forum. We have also reduced the number of essays and now have one essay and cast that into the form of a letter. Rather than have individual in class presentations we have adopted in-class debates to foster critical thinking and skills.

General Reminders

Student Liaison Committee

The Department of Physics and Astronomy values quality teaching and engages in periodic student evaluations of its units, external reviews of its programs and course units, and seeks feedback from students via focus groups and the Student Liaison Committee (SLC). Please consider being a member of the SLC, which meets once during the semester with the purpose of improving teaching via student feedback. Meetings are open and friendly, and invite honest feedback. Student representatives receive a list of outcomes from the preceding meeting. At the beginning of each meeting, an update on responses to feedback is provided by the Head of Department. Feedback is acted upon in a number of ways, mostly initiated via department meetings where decisions on actions are taken.

Standards Expectation

Grades

The broad standards as defined by the academic senate can be found at http://www.mq.edu.au/policy/docs/grading/policy.html.

A marking rubric for the essays will be posted on iLearn to aid you in understanding the key assessment criteria for the essays.