Curriculum
Council

PHYSICS

2

169166_? DOC

IMPORTANT INFORMATION

Overarching Learning Outcomes
1 2 3 4 5 6 7 12 and 13

Accreditation period
2006 – 2010
Aviation Engineering English Media Production and Analysis

2007 – 2011
Accounting and Finance Applied Information Technology Biological Sciences Chemistry Computer Science Drama Earth and Environmental Science English as an Additional Language or Dialect Geography History Ancient and Modern Human Biological Science Literature Music Physical Education Studies Physics Politics and Law Visual Arts

2008 – 2012
Aboriginal and Intercultural Studies Agriculture Australian Indigenous Languages Automotive Engineering and Technology Building and Construction Business Management and Enterprise Career and Enterprise Children Family and Community Dance Economics Food Science and Technology Health Studies Integrated Science LOTE Second Language for Chinese French German Indonesian Italian and Japanese Marine and Maritime Technology Materials Design and Technology Mathematics of Chance and Data Mathematics of Number and Change Mathematics of Space and Movement Philosophy and Ethics Psychology Recreational and Environmental Studies Religion and Life Visual Communication Design

Changes to the study design
This course is accredited for five years During its period of accreditation minor changes to the course will be notified in the Curriculum Council Circular This circular is the only source of changes to regulations and accredited courses and it is the responsibility of each WACE teacher to monitor changes or advice about WACE studies published in the Curriculum Council Circular

Other sources of information
The new WACE Manual contains essential information on assessment moderation and other procedures that need to be read in conjunction with this course
The Curriculum Council will publish updated lists of useful resources and provide online materials to assist teachers in delivering the course
Assessment and Moderation Seminars are held each year to assist teachers
The council website www curriculum wa edu au provides support materials including sample programs schemes of assessment student tasks and student work samples
Training package support materials are developed by RTOs government bodies and industry training advisory bodies to support the implementation of industry training packages Approved support materials are listed at www ntis gov au

WACE providers
Throughout this course booklet the term school is intended to include both schools and other WACE providers

Rationale

Physics is an experimental discipline involving the study of the properties of, and interrelationships between, energy and matter Physics assists us to construct models or explanations of physical phenomena These, in turn allow us to develop a deeper understanding of the world around us For instance, by studying the nature of particles that make up atoms students develop an understanding of the way an electrical circuit works and what measures we can take to protect ourselves and others when working with electricity Physics also allows us to understand why high-speed collisions are more damaging than low-speed collisions, why we may need optical devices to assist our vision, and why gravity, the force that controls the motion of a falling stone can also result in the collapse of a massive star to produce a black hole

Physics, like other scientific disciplines, is continually evolving The practice of physics requires observation, investigation, data collection and data evaluation in order to construct and modify models of physical phenomena The Physics course mirrors scientific processes by encouraging students to refine and reconstruct the models of physical phenomena they already hold in ways that help them to build robust understandings of important concepts The Physics course also encourages the effective communication of those understandings to others

Physics students construct models about how objects and systems interact with one another and how interactions can produce changes The contextual approach of the Physics course helps students both to appreciate the relevance of physics to their everyday experiences, and to gain insight into experiences that are far from the everyday Students achieve the Physics course outcomes by gaining and building on knowledge, skills, understandings and values developed in a range of content areas and contexts

The Physics course caters for students of varying interests and backgrounds Achievement of the course outcomes will allow students to be responsible and efficient users of products and processes at home or in the workplace Students pursuing post-secondary education at TAFE will find that their studies in physics have provided them with foundation knowledge that will support their studies in many areas such as those requiring laboratory and technical skills, as well as those leading to electrical and other physics-related vocations The Physics course also provides prerequisite, preferred or highly desirable knowledge and skills for many science, engineering and science-related courses at tertiary institutions

The Physics course is designed to stimulate and foster intellectual curiosity and promote logical, analytical and reflective thinking It aims to equip students to become informed citizens who are able to communicate their ideas effectively and participate in discussions of challenging issues Students will be encouraged to take an informed and critical interest in science and make decisions on a range of scientific and technological issues that will influence the quality of their lives and the environment

Course outcomes

The Physics course is designed to facilitate the achievement of three outcomes These outcomes come from the Science learning area outcomes in the Curriculum Framework Outcomes are statements of what students should know, understand, value and be able to do as a result of their learning

Outcomes are elaborated into aspects that identify the underpinning knowledge, concepts and/or skills in more detail

Outcome 1 Investigating and communicating in physics

Students investigate physical phenomena and systems, collect and evaluate data, and communicate their findings

In achieving this outcome students

- develop questions and ideas about the physical world to prepare an investigation plan,
- conduct experiments and investigations,
- analyse data and draw appropriate conclusions based on evidence, and
- evaluate the accuracy and precision of experimental data and the effectiveness of their experimental design

Outcome 2 Energy

Students understand energy to explain physical phenomena

In achieving this outcome, students

- understand conceptual models and laws relating to energy
- understand mathematical models and laws relating to energy

Outcome 3: Forces and fields

Students understand forces and fields to explain physical phenomena

In achieving this outcome, students

- understand conceptual models and laws relating to forces and fields,
- understand mathematical models and laws relating to forces and fields, and
- understand the vector nature of forces and some fields

For each outcome there is a course standard consisting of six progressive levels of student achievement

Course content

The essential content needs to be the focus of the learning program It enables students to maximise their achievement of both the overarching learning outcomes from the Curriculum Framework and the Physics course outcomes By engaging with this essential content, students are able to demonstrate their achievement in school-managed tasks and external assessment

The essential content is divided into five content areas

- working in physics (all units)
- forces and motion (units 1A 2A, 3A and 3B)
- waves (units 1B, 2B and 3B)
- electricity and magnetism (units 1B, 2A, 3A and 3B)
- particles (units 1A, 2B, 3B)

Working in physics

Investigating physical systems
Fundamental to the practice of physics is the capacity to safely carry out physical investigations When working in physics students develop fundamental skills and processes used in scientific investigations These skills include the ability to plan manipulate materials and equipment gather information evaluate the significance of data, analyse measure evaluate errors, follow procedures, estimate and process data and concisely and clearly communicate accurate information through written explanations, calculations tables and diagrams and use calculators and other learning technologies as appropriate Students identify real world problems and with direction will develop research tasks to investigate them and develop the skills and understandings needed to explore the physical environment

Making decisions about physical systems
An appreciation of physics and how it affects our lives is important in understanding the nature of physics as a human activity An appreciation of how physical knowledge evolves contributes to an understanding of the importance of physics and equips students with the ability to make ethical decisions about how they use energy and how its use affects people and the environment

Evolution of physical systems
Understanding how people have been, and continue to be, involved in the development and advancement of physics is fundamental to understanding the evolutionary nature of physical knowledge and the scientific processes applied by scientists to solve problems and make decisions As students learn about the development of a small number of crucial ideas that have led to major breakthroughs in physical knowledge they may discern parallels in their own journey to developing an understanding of physics

Problem-solving in physics
As skills and knowledge grow, students develop increasingly sophisticated models of how the laws and principles of physics apply in various situations and how to use them to find solutions to problems Such solutions may be presented in oral, written, calculated, graphical or diagrammatic forms

Forces and motion

Balanced forces and inertia
The study of forces in materials and structures is an important aspect of physics, which may involve analysing single and multiple forces or the moments of forces and ways in which forces and moments act together In learning about balanced forces and motion, students investigate the reasons why things remain at rest and why the motions of some moving bodies change

Unbalanced forces and change
An understanding of displacement, velocity and acceleration forms the basis of the study of forces and movement Motion may be analysed both graphically and numerically and can involve examples that take place in one or more dimensions, such as the motions of a sprinter, a motor vehicle or an aircraft A study of different types of force and the effects of forces is used to build a foundation for the understanding of Newton s Laws momentum and impulse For example, the forces and accelerations involved in circular motion can be linked to the Law of Gravitation to help develop the understanding of circular motion and planetary motion Concepts relating to energy, including its transfer and transformation, are fundamental to the study of physics Connections between energy, work and power can be studied in many contexts and to various depths of understanding both qualitatively and quantitatively Ideas relating to relativity and limitations on space travel may also be explored

Waves

Properties of waves
There are several ways to classify waves such as longitudinal and transverse waves mechanical and electromagnetic waves and travelling and standing waves As they investigate waves, students develop an understanding of characteristics such as speed, frequency wavelength, amplitude, energy, phase the nature of the source and medium They will apply these ideas to the transmission of waves, where interactions between waves and the medium or between waves, lead to phenomena such as absorption, reflection, refraction, total internal reflection diffraction, interference, forced vibration, and resonance, while changes at the source allow modulation of waves

Applications of waves
Students gain an appreciation of the importance of naturally occurring waves in transferring energy such as earthquake waves water and atmospheric

waves and light and in energy transformations, such as in the operation of a microphone or loudspeaker They will understand our reliance on wave motion, especially electromagnetic and sound waves, to communicate information Waves interact with optical systems, including our eyes, spectacles, contact lenses, telescopes binoculars and microscopes They also interact with acoustic systems such as our ears vocal chords and musical instruments to receive or transmit information in forms such as speech or music Students understand that electromagnetic waves can be used in a variety of other ways, including radio and television Students investigate recent advances in optical technology that have led to a multitude of applications such as lasers, CD and DVD technologies, fibre optics and the science of photonics

Electricity and magnetism

Properties and applications of charge
Electric charges interact through electric fields In insulators and isolated conductors this leads to electrostatic interactions In conductors, potential differences may lead to the movement of charge and hence current In studying electrical circuits students investigate energy transfer and transformation through a range of concepts such as direct and alternating current, resistance resistivity, electric potential and potential difference energy and capacitance They will also study and use circuit components such as cells, resistors, switches, capacitors, transistors and diodes Using these concepts and components, students be able to create and control currents and transmit electrical energy within those circuits

Properties and applications of magnetism
Moving charges create and interact through magnetic fields Through their investigations, students encounter a range of magnetic fields such as the earth s magnetic field the fields around permanent or electro-magnets and around current-carrying conductors They will encounter a variety of ways to describe and explain them, such as the domain theory and Ampere's and Maxwell s theories Students also investigate a range of magnetic applications such as the magnetic compass, magnetic shields and magnetic data storage appliances which may include magnetic audio and videotapes and computer hard drives

Interrelationships between electricity and magnetism
Students investigate energy transfer, transformation and electromagnetic phenomena in applications such as transformers generators motors, microphones loudspeakers, audio and video recorders Through their investigations they will develop an understanding of the underlying theories of electricity and magnetism and better understand how scientific knowledge evolves through the historical development of ideas such as those advanced by Ampere, Faraday Henry, Lenz and Maxwell

Particles

Interactions between particles
In developing understandings of the ways in which particles interact with one another students learn about atoms and atomic theory The basic structure of the Rutherford model of the atom will establish the foundation of the subsequent study of radioactivity including quantitative concepts such as atomic number mass number and mass-energy conversions The study of radioactivity includes the common types of radiation sources, uses and hazards of radioactivity, and quantitative aspects such as half-life and the measurement of radioactivity Nuclear reactions, such as decay, fission and fusion possible uses and short and long term advantages and disadvantages of both nuclear and conventional energy sources are important aspects of the course These ideas may be quantified in the study of mass defect and binding energy

Phenomena such as line spectra and the photoelectric effect may be linked to the Bohr model of the atom and may be developed to include quantitative aspects such as the relationship between energy levels in an atom and the frequency of lines involved in line spectra Understand the use of spectral analysis to probe the nature of materials both on earth and elsewhere in the universe

Properties of matter
An understanding of the concepts of temperature heat and internal energy will be used to lay the foundation for the study of the effects of heating and cooling The means by which heat is transferred (including conduction, convection and radiation) and transformed can be studied using many of the real life contexts relevant to this topic Students are required to demonstrate increasing sophistication in their understanding of the Kinetic Theory in order to explain various heat-related phenomena They will develop such thermodynamic concepts as specific heat capacity, latent heat energy conservation and degradation in order to better understand everyday energy use

Course units

To cater for the full range of students, six units have been developed to sequence the syllabus content The units are designed with starting points appropriate for student achievement levels Each of the units is designed around the same essential content areas which increase in complexity from one unit to the next Each unit allows students to achieve all four of the course outcomes

Unit 1APHY

It is recommended that this unit focus on **moving around** and **heating and cooling** Students gain fundamental knowledge about the movement of objects energy relationships involved in movement, and the conditions required for objects to retain their stability and avoid falling over Within the focus of heat, they will learn about temperature measurement, conduction and convection to develop understandings about how heat is transferred through different types of materials

The unit will provide students with opportunities to investigate the behaviour and properties of materials and relate these to the forces that act both within and between the particles of matter Students develop understandings of the effects of forces, Newton's Laws of Motion and conditions for equilibrium to describe and explain motion of objects Through learning about aspects of the Kinetic Theory of Matter and forces between particles, they will understand changes in temperature and state such as why water boils and why ice melts when heated

In their investigations, students identify real world problems and, with direction develop research tasks to investigate these problems developing understandings of, and making decisions in relation to, the physical world

Unit 1BPHY

It is recommended that this unit focus on **seeing things** and **electricity** Within the focus of **seeing things**, students develop fundamental understanding of different types of waves their characteristics and how they transfer energy through a medium **Electricity is** introduced through the study of the relationship between electricity and magnetism atomic structure, electrical charge electrical circuits and the earth s magnetic field

Students learn about the properties of waves and how to represent them symbolically in order to describe their characteristics and explain how they interact with objects and the medium In doing this they will relate physical principles to natural and created systems, such as how our eyes enable us to see objects and to technologies such as photography In learning about electricity and magnetism they will produce and detect electric charges, construct and analyse simple electrical circuits and investigate aspects of electricity and magnetism and how these phenomena lead to a range of technologies and applications

In their investigations students identify real world problems and develop plans to safely conduct an investigation to further their knowledge and understanding of working scientifically and to make decisions in relation to the physical world

Unit 2APHY

It is recommended that this unit focus on **motion and forces** and **electrical fundamentals** Within the focus of **motion and forces** students develop their understanding of motion in one dimension to solve both qualitative and quantitative problems Within the focus of **electrical fundamentals** they will further explore ways that energy is transformed in physical phenomena and extend their understanding of atomic structure, sub-atomic particles and processes that occur within the nucleus

Students learn about force, weight centre of gravity, Newton s laws of motion and the acceleration due to gravity to explain the motion of objects and to represent and interpret this information verbally, graphically and algebraically They add and resolve vectors to expand their understanding of quantitative physical concepts relating to forces and motion They also learn about atomic structure and sub-atomic particles to understand and appreciate phenomena such as those that lead to the emission of nuclear radiation and nuclear energy

They extend their skills related to investigations and effective communication in physics They engage with more specific and abstract questions to select problem-solving strategies that are based on experiences and quantify the error in measurements made in their investigations They begin to develop skills and understandings to enable them to make and evaluate decisions about aspects of their physical environment

Unit 2BPHY

It is recommended that this unit focus on **nuclear physics** and **waves and the Universe** Through the study of light and sound, students further develop their understanding of the characteristics of waves, how they interact with the medium and other waves and how they can be controlled through their interaction with matter In learning about **waves and the Universe**, students apply the concepts of charge and energy transfer to situations involving both electrostatics and current electricity They will construct and study characteristics of electric circuits, learn how to work safely with electricity gain a more comprehensive understanding of the relationship between electricity and magnetism

Students relate physical principles about waves to natural systems, such as the ear and the vocal chords, and to technologies, such as optical fibres, loudspeakers sonar and echo location They will study electrostatic systems and a range of electrical circuits, bringing together quantitative and qualitative understandings They will learn about magnetic fields, how they interact with other fields and how we can put them to use in technology In doing so, they will develop an understanding of the operating principles of a range of electrical and electronic components and systems

They will research a real world problem and plan to carry out safely an investigation, reflect on their experimental design and the implications of their findings They will communicate their findings and conclusions to others and be encouraged to apply their understanding of physical phenomena in making informed decisions or arguing a position on a community issue

Unit 3APHY

It is recommended that this unit focus on **motion and forces in a gravitational field** and **electricity and magnetism** Within the focus of **motion and forces in a gravitational field** students explore the motion of objects in one or two dimensions, circular motion and motion under the effects of gravity The unit will also introduce quantum phenomena to allow students to construct understandings of matter and materials through **electricity and magnetism** including the electron arrangements within atoms and the production of electromagnetic radiation such as visible light infrared, ultraviolet radiation and X-rays

By applying their understanding of motion and forces, students investigate the motion of objects in gravitational fields including the motion of projectiles, orbiting satellites planets and moons, and ways in which forces may affect the stability of extended objects By applying their knowledge of atomic physics, students understand how to analyse spectra and explain a range of physical phenomena such as phosphorescence, fluorescence and why solids glow when strongly heated

Students are given opportunities to develop their skills related to investigating and communicating scientifically They will identify real world problems and develop research questions to inform investigations They will plan and conduct investigations to obtain valid and reliable results and be prepared to justify their findings Responsible attitudes towards investigating the physical world will be fostered

Unit 3BPHY

It is recommended that this unit focus on **particles, waves and quanta** and **motion and forces in electric and magnetic fields** Through further study of light and sound students extend their understanding of waves They will learn about classical and modern interpretations of the nature and behaviour of light and sound In learning about electric and magnetic fields, the study of electricity and magnetism becomes more rigorous as students apply the concepts of charge and energy transfer to situations involving electrostatics, current electricity and electromagnetic induction

Students relate their understandings of how objects produce light and sound and how we can put them to use in related technologies, such as in musical instruments and communication and sensing systems In addition, they will develop an understanding of the operating principles of a range of AC components and systems and of safe practices in using AC, especially at higher voltages

They will research a question relating to a real world problem, taking account of multiple variables collecting suitable data interrogating them for anomalies reflecting upon the investigation, and reformulating the problem if required to inform further investigation They will understand the evolutionary nature of scientific knowledge and may reflect on the impact on society of new understandings in physics

Time allocation

The notional hours for each unit are intended to be 55 class contact hours In an outcomes-focused environment, however, the emphasis is on achievement of the outcomes rather than on the number of hours studied Achievement of outcomes to a desired level may occur in shorter or longer periods of time and schools are encouraged to be flexible in their timetabling in order to meet the needs of all of their students

Course completion

School-managed assessment will provide evidence of achievement of all of the outcomes in each unit At the completion of each unit, schools will provide the Curriculum Council with a level and a band and a number out of 100

Assessment

A scheme of assessment needs to be developed for each class group enrolled in each unit of the Physics course Within this assessment framework, teachers design assessment tasks that meet the learning needs of their students

Refer to the new WACE Manual for details about school-managed and external assessment

The Curriculum Council will commission work to determine assessment procedures that will apply for 2008 and beyond It will take into account teacher feedback, assessment advice already provided to the council and current practices and assessment procedures used in other states Schools will be notified about the assessment approach to be taken from 2008 and beyond on completion of this work

Types of assessment

The three types of assessment in the table below are consistent with the teaching and learning strategies considered to be the most supportive of student achievement of the outcomes in the Physics course The table provides details of the assessment type and examples of different ways that these assessment types can be applied The range of assessments is intended to be inclusive of all students Each type of assessment includes examples that are suitable for both school-managed and external assessment

Types of Assessment
Investigation Research work in which students plan and conduct an open investigation process and interpret data evaluate their plan procedures and findings and communicate their conclusions Investigation findings may be communicated in any appropriate form including written oral graphical or combinations of these Investigation of an open ended research question in physics **and** Practical tasks and/or exercises designed to develop and/or assess a range of laboratory related skills and conceptual understanding of physical principles and skills associated with processing data Types of evidence may include experimental design brief formal investigation or laboratory report report of literature search exercises requiring qualitative and/or quantitative analysis of second hand data evaluation of physical information portfolio of laboratory work reports of simulated laboratory activities PowerPoint/ video/audio presentation of findings and recommendations self or peer evaluation tools and observation checklists In order to fully assess Outcome 1 on at least two occasions in a scheme of assessment teachers must include both of these strategies Best *suited to the collection of evidence of student achievement of Outcomes 1 2 and 3*
Response (extended) Students apply their understanding and skills in physics to analyse and evaluate information prepare reports present responses to extended and/or open-ended questions and solve problems through a combination of work that may be done inside and outside class time Extended tasks that may include a combination of work conducted inside and outside class time that are more open ended and draw on a variety of resources for developing responses to situations of their own or others choosing Types of evidence may include exercises requiring analysis and evaluation of physical information in articles from scientific journals popular media and/or advertising responses to specific questions based on individual research portfolio of work addressing a specific topic PowerPoint/video/audio presentations on a selected topic *Best suited to the collection of evidence of student achievement of Outcomes 1 2 and 3*
Response (analysis) Students apply their understanding and skills in physics to analyse interpret solve problems and answer questions in supervised classroom settings Tasks that are more structured and are conducted in supervised classroom settings These require students to demonstrate use of terminology understanding and application of concepts quantitative skills and knowledge of factual information It is expected that assessment items would include open ended questions to allow students to respond at their highest level of understanding Types of evidence may include diagnostic formative and summative tests and examinations comprehension and interpretation exercises exercises requiring analysis and evaluation of both qualitative and quantitative physical information and responses to discussions and/or presentations *Best suited to the collection of evidence of student achievement of Outcomes 1 2and 3*

Assessment guidelines

- All tasks should take into account teaching, learning and assessment principles from the Curriculum Framework
- There is flexibility within the assessment framework for teachers to design school-managed assessment tasks to meet the learning needs of students
- Student responses may be communicated in any appropriate form (e g written oral graphical multimedia or various combinations of these)
- Student work submitted to demonstrate achievement of outcomes should only be accepted if the teacher can attest that, to the best of her/his knowledge, all uncited work is the student s own
- Evidence collected for each unit should include tasks conducted under test conditions

Examination details

External assessment is a requirement for students aspiring to university selection Students need to complete two units to be eligible to sit the WACE exam

The total examination length is 3 hours and 10 minutes This comprises a written paper of 3 hours working time and 10 minutes reading/planning time It will assess Outcomes 1, 2 and 3 of the course

Vocational Education Training information

Units of competency from selected training package qualifications have been taken into account during the development of this course Physics course outcomes have the potential to encompass some competencies from a variety of training packages through which students may work toward qualifications under the Australian Qualifications Framework

Schools that want to provide students with recognition for achievement of VET units of competency through the Physics course will need to either gain Registered Training Organisation (RTO) status or participate in a partnership with an RTO, and must meet the Australian Quality Training Framework (AQTF) standards and training package requirements If a school operates in partnership with an RTO, it will be the responsibility of the RTO to assure the quality of the training delivery and assessment Qualifications (or parts of them) identified from the Community Services National Training Package for delivery must be registered on the scope of registration of the RTO delivering training in that industry area

Schools that are seeking to link delivery of this course with delivery of units of competency from training packages need to read the information contained in the training package/s

National Training Package
UTE99 Electrotechnology
Qualifications
UTE20604 Certificate II in Electrotechnology

National Training Package
MEM98 Metal and Engineering Industry
Qualifications
MEM10198 Certificate I in Engineering
MEM20298 Certificate II in Engineering

Note Any reference to units of competency from training *packages mentioned are correct at time of accreditation*

Resources

A detailed list of textbooks teacher references, teacher guides and laboratory manuals can be found at
www eddept wa edu au/cmis/eval/curriculum/courses/

COURSE STANDARDS

For each scale of achievement each level is elaborated with indicators of achievement

Teachers will use these to help them make on-balance judgements about student achievement in relation to the outcomes

Outcome 1 Investigating and communicating in physics
Students investigate physical phenomena and systems, collect and evaluate data, and communicate their findings

Aspects	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8
	Students follow instructions collect data describe patterns in the data and describe general difficulties with an experiment	Students using repeat trials or replicates collect and explain patterns in data and make general suggestions to improve an experiment	Students interpret a situation to formulate a question or hypothesis to investigate physical phenomena develop scientific explanations consistent with the data and make specific suggestions for improving the experiment	Students plan an experiment using familiar techniques use preliminary trials to improve their design identify sources of error and estimate the magnitude of an experimental uncertainty and use physics concepts and techniques to explain data and calculate values	Students plan an experiment that goes beyond the familiar carry out the experiment and evaluate the reliability accuracy and precision of the data thus obtained	Students independently formulate an hypothesis design and carry out an experiment and evaluate both the methodology and the conclusions
Students						
• **develop questions and ideas about the physical world to prepare an experiment plan**	• contribute to a group plan to observe or collect data	• contribute to a group plan to observe or collect data using repeated trials or replicates	• formulate a question or hypothesis if given a stimulus and plan data collection procedures and techniques to be used	• use familiar physical techniques to plan an experiment and explicitly link a question or hypothesis to a physics concept or principle	• use reference material to identify and understand a physics problem to investigate and plan an experiment across different aspects of a problem	• working independently formulate a question or hypothesis for testing and use an understanding of variables measurement sample size and repeated trials to design a research proposal including safety considerations and appropriate methodology
• **conduct experiments and experiments**	• follow instructions collect data or observations	• use equipment appropriately and consistently to collect accurate data or observations	• collect data safely make enough measurements to gauge reliability	• use preliminary trials to refine the procedure or data collection techniques and recognise inconsistencies in data	• collect data over a wide enough range of values to ensure reliability recognise when to repeat measurements	• combine design or modify technology or equipment as necessary to collect appropriate data
• **analyse data and draw appropriate conclusions based on evidence, and**	• use a supplied table to display data describe patterns in the data and attempt to write a conclusion	• calculate average values of repeated measurements attempt to explain patterns in the data and write a conclusion that is not necessarily fully consistent with the data	• present data in a table or graph of their own design calculate quantities or values from collected data or by extrapolating or interpolating data on a graph and make conclusions that are consistent with the data	• calculate quantities or values by using the gradient of a graph and explain patterns in the data in terms of physics concepts	• calculate quantities or values by using the inverse gradient or area under the curve of a graph explain conclusions using physics concepts relate conclusions to the question or hypothesis and explicitly show that conclusions are consistent with their own and/or others data	• evaluate conclusions to reformulate an ongoing experiment and to plan follow up experiments
• **evaluate the accuracy and precision of experimental data and the effectiveness of experimental design**	• State whether or not their conclusions are consistent with accepted values or models describe general difficulties encountered during the experiment	• offer simple explanations for inconsistencies between their conclusions and accepted values or models and suggest general changes for improving the experiment	• suggest specific changes for improvement of techniques or the design of the experiment	• identify major sources of error suggest improvements to specifically target error reduction and estimate absolute uncertainties in data	• distinguish between accuracy and precision of data recognise limitations in data collection and control of variables and estimate percentage uncertainties in data	• allow for anomalous data when presenting data and drawing conclusions and estimate percentage and absolute uncertainties in their conclusions

Course standards

Outcome 2 Energy
Students understand energy to explain and predict physical phenomena

Aspects	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8
	Students understand that energy and related concepts can be represented using agreed symbols	Students understand that energy and related concepts can be represented using models	Students understand that a model of energy or a related concept can be used to explain and predict physical phenomena	Students understand that changes in or relationships within a model of energy or a related concept can be used to explain and predict physical phenomena	Students understand that models of energy and related concepts can be combined to explain and predict physical phenomena	Students understand that multiple models of energy and related concepts can be used to explain and predict physical phenomena
Students						
• **understand conceptual models and laws relating to energy**	• identify physical quantities and systems *e g distinguish between kinetic energy potential energy and internal energy*	• describe the main features of a conceptual model or a physical system *e g state that energy is a scalar quantity* *e g state that a particular object has kinetic energy potential energy internal energy or a combination of these*	• relate the main physical quantities in a conceptual model or a physical system to one another *e g state that the kinetic energy of a falling object increases as the object s gravitational potential energy decreases*	• explain or predict the effect of a change in a conceptual model or physical system *e g explain that the gravitational potential energy of an object will decrease if the object s altitude decreases*	• relate events or interactions in a physical system to an underlying conservation principle or law *e g apply the principle of energy conservation to explain that a bungee jumper will oscillate as energy transfers from gravitational potential to kinetic to elastic potential and so on*	• relate events or interactions in a physical system to two or more underlying principles or laws *e g explain that the gravitational potential energy of a bungee jumper is stored in the Earth s gravitational field while the elastic potential energy in a stretched bungee cord is stored in the electric fields around its molecules*
• **understand mathematical models and laws relating to energy**	• relate symbols to physical quantities *e g state what E_k m and v represent in the equation $E_k=\frac{1}{2}mv^2$*	• evaluate an answer in one step given a mathematical model *e g use $E_k=\frac{1}{2}mv^2$ to find E_k if given the equation*	• select and use a mathematical model to evaluate an answer in one step *e g use $E_k=\frac{1}{2}mv^2$ to find E_k* *e g interpret a graph of E_k vs h for a given object*	• select and use a mathematical model to evaluate an answer in more than one step *e g use $E_k=\frac{1}{2}mv^2$ to find v* *e g sketch a graph of E_k vs h for a given object* *e g determine the efficiency of an energy transfer process*	• derive a new model by selecting and combining or using sequentially two known models *e g combine or use sequentially $Ft=mv$ mu and $E_k=\frac{1}{2}mv^2$ to find u* *e g use a graph of E_k vs h for a falling object to determine the vertical velocity at a given height*	• derive a new model by selecting and combining or using sequentially more than two known models *e g use conservation of energy to predict the maximum height reached by a projectile given its launch parameters* *e g sketch a graph of E_k vs h for a vertical projectile given its initial vertical momentum*

Course standards

Outcome 3 Forces and fields Students understand forces and fields to explain and predict physical phenomena						
Aspects	**Level 3**	**Level 4**	**Level 5**	**Level 6**	**Level 7**	**Level 8**
	Students understand that forces fields and related concepts can be represented using agreed symbols	Students understand that forces fields and related concepts can be represented using models	Students understand that a model of force field or a related concept can be used to explain and predict physical phenomena	Students understand that changes in a model of force field or a related concept can be used to explain and predict physical phenomena	Students understand that models of forces fields and related concepts can be combined to explain and predict physical phenomena	Students understand that multiple models of forces fields and related concepts can be used to explain and predict physical phenomena
Students						
• **understand conceptual models and laws relating to forces and fields**	• identify physical quantities and systems e g *distinguish between acceleration and speed*	• describe the main features of a conceptual model or a physical system e g *state Newton s second law*	• relate the main physical quantities in a conceptual model or a physical system to one another e g *state that an accelerating object must have a net force acting on it* e g *interpret a graph of F vs a for a given object*	• explain or predict the effect of a change in a conceptual model or physical system e g *predict that a given force will produce a greater acceleration in an object of lower mass* e g *sketch a graph of F vs a for a given object*	• relate events or interactions in a physical system to an underlying conservation principle or law e g *apply the principle of conservation of momentum to explain how a rocket works in a vacuum*	• relate events or interactions in a physical system to two or more underlying principles or laws e g *use the principles of conservation of momentum and conservation of energy to explain elastic collisions* e g *sketch a graph showing how the momentum of a vertically launched projectile varies with time*
• **understand mathematical models and laws relating to forces and fields**	• relate symbols to physical quantities e g *state what F m and a represent in the equation F=ma*	• evaluate an answer in one step given a mathematical model e g *use F=ma to find F if given the equation*	• select and use a mathematical model to evaluate an answer in one step e g *use F=ma to find F*	• select and use a mathematical model to evaluate an answer in more than one step e g *use* $F=G\frac{m_1 m_2}{r^2}$ *to find r*	• derive a new model by selecting and combining or using sequentially two known models e g *combine or use sequentially* $F=G\frac{m_1 m}{r^2}$ *and* $F=\frac{mv}{r}$ *to find v*	• derive a new model by selecting and combining or using sequentially more than two known models e g *predict the impact velocity of a projectile given its launch parameters*
• **understand the vector nature of forces and some fields**	• state the difference between scalar and vector quantities e g *state that vector quantities have an associated direction*	• identify physical quantities that are vectors e g *identify force displacement or acceleration as vector quantities*	• add vectors in one dimension e g *find the sum of 5m north and 7m south* • resolve a vector into rectangular components e g *find the N and W components of 5m NW*	• subtract vectors in one dimension e g *can subtract 5m north from 7m south* • add perpendicular vectors in two dimensions by first resolving them into components or graphically e g *find the sum of 5m north and 7m east* • represent a system of perpendicular forces in two dimensions as a free body diagram e g *draw a free body diagram for a vehicle travelling along a straight horizontal road*	• add non perpendicular vectors in two dimensions either by first resolving them into components or graphically e g *find the sum of 5m south east and 7m north 30° west* • subtract perpendicular vectors in two dimensions by first resolving them into components or graphically e g *subtract 5m south east from 7m south west* • represent a system of non perpendicular forces in two dimensions as a free body diagram e g *draw a free body diagram for a vehicle rounding a bend*	• subtract non perpendicular vectors in two dimensions either by first resolving them into components or graphically e g *subtract 5m south east from 7m north 30° west*

UNIT 1APHY

Suggested entry levels up to 3/4

Unit description

Unit learning contexts

Within the broad focus areas of **moving around** and **heating and cooling**, teachers may choose one or more of the following contexts (this list is not exhaustive)

Moving around
- wheels
- on your own two feet
- trains boats and planes

Heating and cooling
- temperature control
- heat and motor vehicles
- food preparation and preservation
- global warming

Unit content

This unit of study includes knowledge, understandings and skills with the degree of complexity described below

Working in physics

Investigating physical systems

Given a context students plan and conduct experiments safely collect data and make conclusions They may work individually on some tasks and contribute within collaborative groups on other tasks Examples of suitable investigations could include
- collecting and analysing data relating to the motion of a moving vehicle
- examining the thermal properties of a range of materials

Problem solving in physics

Students interpret and suggest answers to a variety of authentic, real world physical problems

Moving around

Balanced forces and inertia
- distance, displacement, speed, velocity mass inertia, force weight acceleration, energy, work and their units
- Newton's first law of motion, equilibrium, and the necessary conditions for stable, unstable and neutral equilibrium
- uniform rectilinear motion
- graphical representation of motion in one dimension

Unbalanced forces and change
- uniformly accelerated motion
- average speed
- forces and their effects including pushes and pulls
- contact forces and non-contact forces
- effects of forces on objects in the presence or absence of friction
- Newton's laws of motion
- energy
- relationships between energy and work, kinetic energy and gravitational potential energy
- work
- conservation of energy

Heating and cooling

Interactions between particles
- matter as a collection of atoms, structure of the atom
- historical perspectives on the nature of matter
- Kinetic theory of matter and its application to explain the properties of matter and changes of state

Properties of matter
- heat and temperature
- sources of heat
- heat transfer (conduction, convection and radiation)
- conversion of different forms of energy into heat
- conservation of energy
- energy degradation

VET units of competency

Units of competency may be delivered in **appropriate** learning contexts if students are aiming to have the competency assessed

MEM2 5C11A Measure with graduated devices
MEM2 7C10A Perform computations – basic

UNIT 1BPHY

Suggested entry levels up to 3/5

Unit description

Unit learning contexts

Within the broad focus areas of **seeing things** and **electricity**, teachers may choose one or more of the following contexts (this list is not exhaustive)

Seeing things

- vision
- photography

Electricity

- using electricity at home
- safety with electricity
- car electrical systems

Unit content

This unit of study includes knowledge, understandings and skills with the degree of complexity described below

Working in physics

Investigating physical systems

Given a context students plan and carry out investigations safely collecting data, using an array of measuring skills appropriate to physics and make inferences based on that data Examples of suitable investigations could include

- examining the electrical conducting or insulating properties of a range of materials
- change in direction of waves as they enter a different medium or travel through narrow openings

Problem solving in physics

Students will read, interpret and provide answers to a variety of authentic, real world physical problems

Seeing things

- distinguish between real and virtual images
- explain the action of mirrors (plane converging and diverging) in terms of reflection
- explain the action of lenses (converging and diverging) in terms of refraction
- describe the formation of images by converging and diverging lenses
- explain the appearance of coloured objects in terms of their absorption and reflection or transmission of light

Electricity

- construct simple electrical circuits and measure current and potential difference at various points around the circuit
- draw and interpret simple circuits and circuit diagrams including the use of standard symbols for resistor (fixed and variable), light bulb, switch, ammeter voltmeter, dry cell and power supply
- describe electrical current through series and parallel circuits

Interrelationships between electricity and magnetism

- evidence for the creation of magnetic fields by moving charges

VET units of competency

Units of competency may be delivered in **appropriate** learning contexts if students are aiming to have the competency assessed

UTENES001BA Undertake basic work activities (electrical)
MEM2 5C11A Measure with graduated devices
MEM2 7C10A Perform computations – basic

UNIT 2APHY

Suggested entry levels up to 4/5

Unit description

Unit learning contexts

Within the broad focus areas of **motion and forces** and **electrical fundamentals,** teachers may choose one or more of the following contexts (this list is not exhaustive)

Motion and forces

- running, jumping and standing still
- toys and simple machines
- vehicle safety and collisions

Electrical fundamentals

- car electrical systems
- domestic power
- electrical safety
- direct current devices

Unit content

This unit of study includes knowledge understandings and skills with the degree of complexity described below

Working in physics

Investigating physical systems

Given a problem, students identify a hypothesis or question and plan and carry out physical experiments and investigations They write conclusions and evaluate their experimental design They reflect on what they have done, what they have found out and the implications of their findings Investigations should provide students with opportunities to make observations, measure a range of variables, discuss measurement uncertainties and compare experimental data to accepted values Examples of suitable investigations include

- collecting and analysing distance and time data about accelerating vehicles
- how the

Problem solving in physics

Students interpret and provide answers for a variety of authentic, real world physical problems both of a qualitative and quantitative nature Using the information provided in a question, students may use graphical and/or mathematical techniques to propose solutions to the question When solving problems, students should show how they arrived at an answer

Motion and forces

Consider the level of uncertainty in experimental measurements and conclusions, and when solving numerical problems

- distinguish between scalar and vector quantities, and *add and subtract vectors in one dimension*
- explain and apply the concepts of distance and displacement, speed and velocity, and acceleration in the context of uniform and uniformly accelerated rectilinear motion, including vertical motion under gravity This will include *applying the relationships*

  $v_{av} = \frac{s}{t}$, $v_{av} = \frac{v+u}{2}$ $a = \frac{v-u}{t}$,

  $s = ut + \frac{1}{2}at^2$, $v^2 = u^2 + 2as$
- state, explain and apply Newton's First, Second and Third Laws of motion This will include *applying the relationship* resultant $F = ma$
- explain that point masses create radial gravitational fields Describe, using diagrams gravitational field distributions around simple combinations of masses Describe, explain and use gravitational fields to explain weight as the force on a mass in a gravitational field This will include *applying the relationship* $F = mg$
- draw free body diagrams, showing the forces acting on objects, from descriptions of real life situations involving forces acting in one dimension
- explain and apply the law of conservation of momentum in one dimension This will include *applying the relationships*

  $p = mv$, $p_{before} = p_{after}$, $Ft = mv - mu$
- explain and apply the concepts of energy and work including kinetic energy, gravitational potential energy, and internal energy State, explain and apply the principle of conservation of energy in situations involving transfer of energy, and work This will include *applying the relationships*

  $E_k = \frac{1}{2}mv^2$, $E_p = mg\Delta h$, $W = Fs$, $W = \Delta E$
- explain and apply that power is the rate of doing work or transferring energy This will include *applying such relationships as* $P = \frac{W}{t}$

Electrical fundamentals

- explain that atoms can gain or lose electrons so gaining a net charge, and state that like charges repel and unlike charges attract
- explain and apply the concept of electric current' as the rate of flow of electric charge in an electric field This will include *applying the relationship* $I = \frac{q}{t}$
- state that the direction of conventional current is that in which the flow of positive charge takes

place while the electron flow is in the opposite direction

- explain using electric fields the connection between electrical work, charge and potential difference This will include *applying the relationships of electrical work and power*
  Work = qV = VIt   P = VI
- draw and interpret simple circuit diagrams including the use of standard symbols for resistor (fixed and variable), light bulb, switch, ammeter, voltmeter, dry cell and power supply
- understand and apply the concepts of electrical current, potential difference and resistance in series and parallel circuits
- explain and apply Ohm's Law and the concepts of ohmic and non-ohmic conduction This will include *applying the relationship* V = IR
- determine the total resistance of a number of resistors in series using $R_T = R_1 + R_2 +$
- determine the total resistance of a number of resistors in parallel using $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} +$
- connect components in simple circuits and measure, or *predict and verify, values of current and potential difference* using ammeters and voltmeters
- identify energy transfers in electrical circuits and devices
- explain the cause of electric shock, and identify hazardous situations and safety precautions in everyday uses of electrical energy
- explain the electrical principles behind the operation of various safety devices

VET units of competency

Units of competency may be delivered in **appropriate** learning contexts if students are aiming to have the competency assessed

MEM2 5C11A Measure with graduated devices
MEM2 7C10A Perform computations – basic

UNIT 2BPHY

Suggested entry levels up to 4/6

Unit Description

Learning contexts

Within the broad focus areas of **Nuclear physics** and **Waves and the Universe** teachers may choose one or more of the following contexts (this list is not exhaustive)

Nuclear physics

- Nuclear energy
- Radioisotopes,
- Medical imaging and therapies

Waves and the Universe

- Astronomical observations
- Space travel and science fiction
- Water waves,
- Earthquakes

Essential content

This unit of study includes knowledge, understandings and skills with the degree of complexity described below

Working in Physics

Investigating physical systems Students identify a problem suitable for investigation, reformulate it as a testable hypothesis, plan an ethical investigation (perhaps involving a number of controlled variables) and carry it out They reflect on what they have done, what they have found out and the implications of their findings

Student investigations should include opportunities to make observations, measure a range of variables, estimate errors, and compare experimental data to accepted values Examples of suitable investigations include collecting and analysing potential and current data from series and parallel collections of electrical resistors or the effect of different angles of incidence on the angle of reflection or refraction of a wave at an interface

Problem solving in physics Students interpret data and provide answers for a variety of authentic real world physical problems both of a qualitative and quantitative nature Using relevant information students may use graphical and/or algebraic techniques to propose solutions to the question When solving problems they explain the logic in arriving at an answer

Nuclear Physics

Consider the level of uncertainty in experimental measurements and conclusions, and when solving numerical problems

Explain and apply the concepts of atomic number, mass number, isotope, atomic mass unit and nuclide

Explain that many nuclides are unstable and that these nuclides decay

Explain and apply the differences and similarities in the nature and properties of α, β and γ radiation

Write and interpret equations relating to alpha beta and gamma decay

Explain that ionising radiation causes atoms to lose electrons, and thus become charged

Explain and apply the concepts of *half-life, activity, dose and dose equivalent*, and describe the effects of ionising radiation on humans

Explain and apply the concepts of mass defect and binding energy of nuclides This will include *applying the relationships* $\Delta E = (\Delta m)c^2$ *and that 1 u of mass is equivalent to 931 5 MeV of energy*

Explain the concepts of neutron-induced fission chain reactions and critical mass

Explain and apply the concept of variation in binding energy per nucleon of nuclides to explain the release of energy by both fission and fusion processes This will include *applying the relationships* $\Delta E = (\Delta m)c^2$ *and that 1 u of mass is equivalent to 931 5 MeV of energy*

Explain that *energy released during nuclear fission* can be used to generate electrical energy in the same way as the energy released by burning fossil fuels

Explain that *energy produced by nuclear fusion* is the ultimate source of solar energy

Describe and explain both advantages and disadvantages of nuclear power stations and other applications of nuclear technology

Waves and the Universe

Describe and explain the scale of observable entities from sub-atomic particles to the Universe

Apply the speed of light in vacuum to astronomical distances to predict and explain transit times of light and particles travelling between planets, stars and galaxies This will include *applying the relationship*

$$v_{av} = \frac{s}{t}$$

Describe and apply the speeds of astronomical bodies such as the Moon and the Earth in their orbits, or the speeds of galaxies This will include *applying the relationship* $v_{av} = \frac{s}{t}$

Describe and explain the expansion of the Universe and Hubble's law

Describe and explain electromagnetic radiation and the spectrum

Describe and explain how astronomical observations exploit differences in properties of the various parts of the emr spectrum in order to gather more information about celestial bodies

Explain and apply that a wave is a means of energy transfer

Explain and apply the concepts of wavefronts & rays, *wave speed, wavelength, frequency, period,* *amplitude, phase* This will include *applying the relationships*

$$v_{wave} = \frac{s}{t}, \quad v_{wave} = f\lambda \quad f = \frac{1}{T}$$

VET Units of Competency

Units of competency may be delivered in **appropriate** learning contexts if students are aiming to have the competency assessed

UTENES001BA Undertake basic work activities (Electrical)
UTENES201BA Perform basic repair to electrical/electronic apparatus
UTENES401BB Perform functional apparatus checks (Electrical)
MEM2 5C11A Measure with graduated devices
MEM2 7C10A Perform computations – basic

UNIT 3APHY

Suggested entry levels up to 5/7

Unit Description

Learning contexts

Within the broad focus areas of **Motion and forces in a gravitational field** and **Electricity and magnetism**, teachers may choose one or more of the following contexts (this list is not exhaustive)

Motion and forces in a gravitational field

- Playground equipment,
- Physics in sport,
- Space travel
- Planetary motion,
- Fairground physics,
- Bridges and buildings

Electricity and magnetism

- Electric toys
- Power generation and distribution,
- Motors and generators

Essential content

This unit of study includes knowledge, understandings and skills with the degree of complexity described below

Working in Physics

Investigating physical systems Students design analyse and evaluate ethical experiments and investigations, proposing and testing their hypothesis controlling a number of variables analysing data and reformulating the problem if required They identify anomalies in data and distinguish between association and causality when drawing conclusions

Examples of suitable investigations may include collecting and analysing spectral data from various gas discharge tubes, an examination of single and double slit interference, or examining the relationship between the radius and speed of revolving bodies

Problem solving in physics When solving problems, students document their problem solving technique, make explicit assumptions, and estimate physical quantities for inclusion in formulas and in their solutions They check that calculated results are reasonable

Motion and forces in a gravitational field

Consider the level of uncertainty in experimental measurements and conclusions, and when solving numerical problems

Explain and apply the principle of conservation of energy

Resolve, add and subtract vectors in one plane

Draw free body diagrams, showing the forces acting on objects, from descriptions of real life situations involving forces acting in one plane

Explain and apply the concepts of distance and displacement, speed and velocity, and acceleration in the context of motion in a plane, including the trajectories of projectiles in the absence of air resistance This will include *applying the relationships*

$$v_{av} = \frac{s}{t}, \quad v_{av} = \frac{v+u}{2}, \quad a = \frac{v-u}{t},$$

$$s = ut + \tfrac{1}{2}at^2, \quad v^2 = u^2 + 2as$$

Describe qualitatively the effects of air resistance on projectile motion

Explain and apply the concepts of centripetal acceleration and centripetal force, as applied to uniform circular motion This will include *applying the relationships*

$$a_c = \frac{v^2}{r} \quad \text{resultant } F = ma = \frac{mv^2}{r}$$

Explain and apply the concept of centre of mass

Explain and apply Newton's Law of Universal Gravitation and the concept of gravitational acceleration, g, as gravitational field strength This will include *applying the relationships*

$$F_g = G\frac{m_1m_2}{r^2}, \quad g = G\frac{M}{r^2}$$

Explain the conditions for a satellite to remain in a stable circular orbit in a gravitational field, and calculate the parameters of satellites in stable circular orbits This will include *applying the relationships*

$$v_{av} = \frac{s}{t}, \quad a_c = \frac{v^2}{r}, \quad \text{resultant } F = ma = \frac{mv^2}{r},$$

$$F_g = G\frac{m_1m_2}{r^2}, \quad g = G\frac{M}{r^2}$$

Explain and apply the concept of torque or moment of a force about a point, and the principle of moments, and their application to situations where the applied force is perpendicular to the lever arm This will include *applying the relationships*

$\tau = rF$ and $\Sigma\tau = 0$

Explain and apply the concept of a rigid body in equilibrium This will include *applying the relationships*

$\Sigma F = 0 \quad \tau = rF$ and $\Sigma\tau = 0$

Electricity and magnetism

Explain the attraction and repulsion effects for magnets, the behaviour of freely suspended magnets and magnetic compasses, and describe the nature of the Earth's magnetic field

Describe, using diagrams, the magnetic field in various magnetic configurations

Explain that magnetic fields are associated with moving charges, and draw the field due to a current flowing through a long straight wire, a short coil and a solenoid

Distinguish between direct and alternating currents and potentials

Explain and apply the concept of force on a conductor in a magnetic field, and describe the factors which affect the force on a current-carrying conductor in a magnetic field This will include *applying the relationship* $F = I\ell B$ for perpendicular cases

Explain the force acting on the electrons in a metallic conductor moving in a magnetic field, and apply this concept to explain the torque produced by the force on a rectangular coil carrying a current in a magnetic field This will include *applying the relationships* $F = I\ell B$ and $\tau = rF$ for perpendicular cases

Explain and apply the concepts of magnetic flux and magnetic induction This will include *applying the relationships* $\Phi = BA$, induced emf $= -N\dfrac{\Delta\Phi}{\Delta t}$,

induced emf $= \ell vB$

Interpret and explain situations involving induced emf, such as the AC generator, and Lenz's Law applications

Explain using electric fields the connection between electrical work, charge and potential difference This will include *applying the relationships of electrical work and power*

$$\text{Work} = qV = VIt, \qquad P = VI = I^2R = \frac{V^2}{R}$$

Explain and apply the principle of the transformer This will include *applying the relationship*

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

Explain why electrical power is transmitted as AC at very high voltages

Discuss the major environmental impacts of

VET Units of Competency

Units of competency may be delivered in **appropriate** learning contexts if students are aiming to have the competency assessed

UNIT 3BPHY

Suggested entry levels up to 6/8

Unit Description

Learning contexts

Within the broad focus areas of **Particles, waves and quanta** and **Motion and forces in electric and magnetic fields**, teachers may choose one or more of the following contexts (this list is not exhaustive)

Particles, waves and quanta

- Medical imaging and therapies,
- Colours of fireworks,
- Sunlight and starlight,
- Sonar and echo-location,
- Optical fibres,
- Musical instruments,
- Communication systems,
- Security/remote sensing systems

Motion and forces in electric and magnetic fields

- Particle accelerators,
- Cathode ray oscilloscopes,
- Mass spectrometry

Essential content

This unit of study includes knowledge, understandings and skills with the degree of complexity described below

Working in Physics

Investigating physical systems Students design, analyse and evaluate ethical experiments and investigations, proposing and testing their hypothesis, controlling a number of variables, analysing data and reformulating the problem if required They identify anomalies in data and distinguish between association and causality when drawing conclusions They consider implications, potential issues and applications of their research findings

Suitable examples may include analysing sound levels at varying distances from a musical instrument or loudspeaker, or the effect of different input currents on the efficiency of an electric motor

Problem solving in physics When solving problems, students document their problem solving technique, make explicit assumptions, and estimate physical quantities for inclusion in formulas and in their solutions They recognise that assumptions made allow them to draw qualified conclusions They check that calculated results are reasonable

Particles, waves and quanta

Consider the level of uncertainty in experimental measurements and conclusions, and when solving numerical problems

Explain and apply the concepts of amplitude, frequency, wavelength, displacement and speed of longitudinal and transverse mechanical waves This will include *applying the relationships*

$T = \frac{1}{f}$, $v = f\lambda$

Explain and apply the concepts of reflection and diffraction of wave fronts

Explain that the speed of a wave varies with the medium, and use this to explain the cause of refraction in terms of a change in the speed of wave as it crosses an interface

Explain and apply the concepts of absolute refractive index of a given medium, Snell's Law, total internal reflection critical angle and dispersion This will include *applying the relationships*

$n_x = \frac{c_0}{c_x}$, $n_1 \sin\theta_1 = n_2 \sin\theta_2$, $\angle i = \angle r$

Explain and apply the concepts of free oscillations, forced oscillations, and standing waves This will include identifying nodes and antinodes, and *using the expression* $\text{internodal distance} = \frac{1}{2}\lambda$

Sketch diagrams to illustrate the behaviour of waves in a variety of situations

Describe and explain the nature and properties of electromagnetic waves, including the concept of light as a wave of changing electric and magnetic fields, and its wave and particle properties

Classify emr spectra as emission spectra and absorption spectra and as line, broadband and continuous spectra

Explain and interpret line emission spectra, line absorption spectra and ionisation using the Bohr model of the atom and the concepts of ground and excited states, photons, quanta and energy level transitions This will include *applying the relationships*

$c = f\lambda$, $E = hf$, $E_2 - E_1 = hf$

Explain fluorescence and the generation of X-rays This will include *applying the relationships*

$c = f\lambda$, $E = hf$, $E_2 - E_1 = hf$

Extend the concept of subatomic particle to include neutrinos and quarks

Describe and explain wave-particle symmetry relationships including the de Broglie wavelength and the Heisenberg uncertainty principle

Describe and explain qualitative aspects of the special theory of relativity such as reference frames and the equivalence principle

Describe and explain fundamental cosmological concepts such as red shift, the curvature of space, the Big Bang theory and the history and future of the Universe

Force and motion in electric and magnetic fields

Explain that point charges create radial electric fields

Describe, using diagrams, electric field distributions around simple combinations of charged points, spheres and plates

Describe, explain and use electric fields between parallel plates and within uniform conductors, to explain the forces on charged particles This will include *applying the relationships* $E = \frac{F}{q} = \frac{V}{d}$

Explain and apply the concept of force on a charged particle moving through a magnetic field This will include *applying the relationships* $F = qvB$, $F = \frac{mv^2}{r}$

Describe the factors which affect the force on a charged particle moving through a magnetic field

Explain and apply the concepts of electric and magnetic field in combination e g in sequence in a CR tube, or in combination in a velocity filter This will include *applying the relationships*

$$E = \frac{F}{q} = \frac{V}{d}, \quad F = qvB, \quad F = \frac{mv^2}{r}$$

VET Units of Competency

Units of competency may be delivered in **appropriate** learning contexts if students are aiming to have the competency assessed

PHYSICS SAMPLE EXAMINATION

Section 7 of the *New WACE Manual General Information 2006–2009* outlines the policy on WACE examinations

Further information about the WACE Examinations policy can be accessed from the Curriculum Council website at
http //newwace curriculum wa edu au/pages/about_wace_manual asp

The purpose for providing a sample examination is to provide teachers with an example of how the course will be examined Further finetuning will be made to this sample in 2007 by the examination panel following consultation with teachers, measurement specialists and advice from the Assessment, Review and Moderation (ARM) panel

Curriculum Council

Sample Examination

Question/Answer Booklet

PHYSICS

Please place your student identification label in this box

Student Number In figures | | | | | | | | |

In words ______________________________

____

Time allowed for this paper

Reading time before commencing work Ten minutes
Working time for paper Three hours

Material required/recommended for this paper

To be provided by the supervisor

This Question/Answer Booklet, Formulae and Constants sheet

To be provided by the candidate

Standard items Pens, pencils, eraser or correction fluid, ruler, highlighter

Special items Calculator

Important note to candidates

No other items may be taken into the examination room It is **your** responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room If you have any unauthorised material with you, hand it to the supervisor **before** reading any further

Any calculations are to be set out in detail Marks will be awarded for correct equations and clear setting out, even if you cannot complete the calculation Express numerical answers to three (3) significant figures and provide units where appropriate

Structure of this paper

Section	Addressing Units	Outcomes	Suggested working time	Number of questions available	Number of questions to be attempted
A	Compulsory 2A, 2B, 3A, 3B	1, 2 and 3	60 minutes	8	8
B	2A	1, 2 and 3	60 minutes	8	8
C	2B	1, 2 and 3	60 minutes	8	8
D	3A	1, 2 and 3	60 minutes	8	8
E	3B	1, 2 and 3	60 minutes	8	8

Instructions to candidates

1 The rules for the conduct of Curriculum Council examinations are detailed in the *Student Information Handbook* Sitting this examination implies that you agree to abide by these rules

2 Answer the questions according to the following instructions

Section A Common Section This section is compulsory Answer **all** questions in the spaces provided in this Question/ Answer Booklet

Section B CHOOSE this section if you have studied **2A** as ONE of your latest pairs of Physics units

Section C CHOOSE this section if you have studied **2B** as ONE of your latest pairs of Physics units

Section D CHOOSE this section if you have studied **3A** as ONE of your latest pairs of Physics units

Section E CHOOSE this section if you have studied **3B** as ONE of your latest pairs of Physics units

3 For the sections you have chosen, answer **all** questions in the spaces provided in this Question/Answer Booklet

4 A blue or black ball point or ink pen should be used

SECTION A–Compulsory section

This section has **EIGHT (8)** questions Attempt **ALL** questions in the spaces provided

Allow approximately 60 minutes to complete this section *[68 marks]*

Question A1
While at anchor, some distance from the coast, a sailor noticed that waves passed his ship every 37 seconds

(a) What was the period of these waves?

[1 mark]

(b) What was the wave frequency?

[2 marks]

(c) How many such waves would pass the ship in a time interval of 5 0 minutes?

[2 marks]

Question A2
The frequency of red light is $4\ 3 \times 10^{14}$ Hz When this light travels through glass, its wavelength in the glass is $4\ 7 \times 10^{-7}$ m

(a) Calculate the speed of red light in glass

[3 marks]

(b) Green light has frequency $5\ 7 \times 10^{14}$ Hz The speed of green light in the same glass would be

[1 mark]

A significantly greater than the speed of red light

B approximately the same as the speed of red light

C significantly less than the speed of red light

Question A3
Asha ran 40 0 m north, then 50 0 m south
(a) What was Asha's displacement?

[2 marks]

(b) If the total time for the run was 15 6 s, what was her average speed?

[3 marks]

Question A4

A 1 500 kg car accelerates down a long straight road at 2 75 m s^{2} What overall force must be acting on the car while it accelerates?

[3 marks]

Question A5

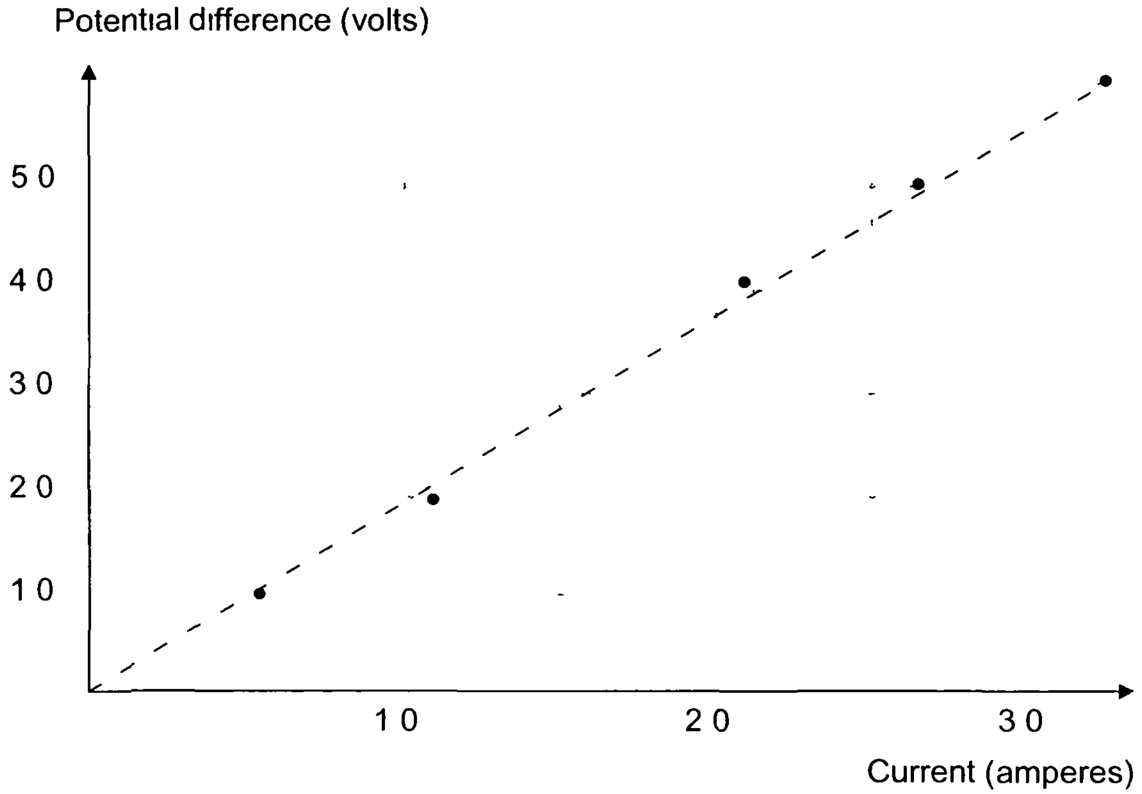
A light bulb is marked '250 V, 60 W' What is the normal operating current of this bulb?

[3 marks]

Question A6

Geraldine conducted an investigation to determine the relationship between current and potential difference in a resistor

Geraldine measured the current through a resistor of resistance R Ω, at various values of potential difference across the resistor She recorded her data in a graph, and drew a line of best fit for the data, as reproduced below



(a) Geraldine did not measure the current at a potential difference of 3 0 V Use the graph to determine the current she would have measured at 3 0 V

[2 marks]

____

____

(b) Geraldine forgot to record the value of the resistance, R Use the graph to determine the value (in Ω) of the resistance R

[4 marks]

____

____

____

____

(c) Using the graph, determine the power dissipated in the resistor when the potential difference is 4 0 V

[4 marks]

(d) Using the graph, determine the energy dissipated in 20 0 seconds when the current through the resistor is 2 5 A

[4 marks]

Question A7

A group of engineering students decided to investigate the problems of high speed and stopping distances after a series of road accidents around their university.

They investigated stopping distances required by twenty drivers, each driving one of four 2004 identical cars on a dry road in normal daylight. The drivers were required to respond to a visual signal, simulating a child running in front of the car. Electronic recorders registered the distance travelled by the car between the time that the signal was triggered and the instant that the driver applied the brakes. This was recorded as the 'thinking distance'. The recorders then registered the distance travelled by the car while the brakes were applied. This was recorded as the 'braking distance'.

The following table shows their results.

Initial speed, km h^{-1}	Initial speed, m s^{-1}	Average thinking distance, m	Average braking distance, m	Average total stopping distance, m	Average acceleration while braking, m s^{-2}
30	8.3	6.0	6.0	12	-5.7
45	12	9.0	14	23	-5.1
60	17	12	24	36	-6.0
75	21	17	38	55	-5.8
90	25	18	55	73	-5.7
105	29	21	75	96	-5.6

(a) State one variable which the investigators decided to measure, and two variables that the investigators controlled to make their test fair.

[3 marks]

They measured ____

____

They controlled ____

____

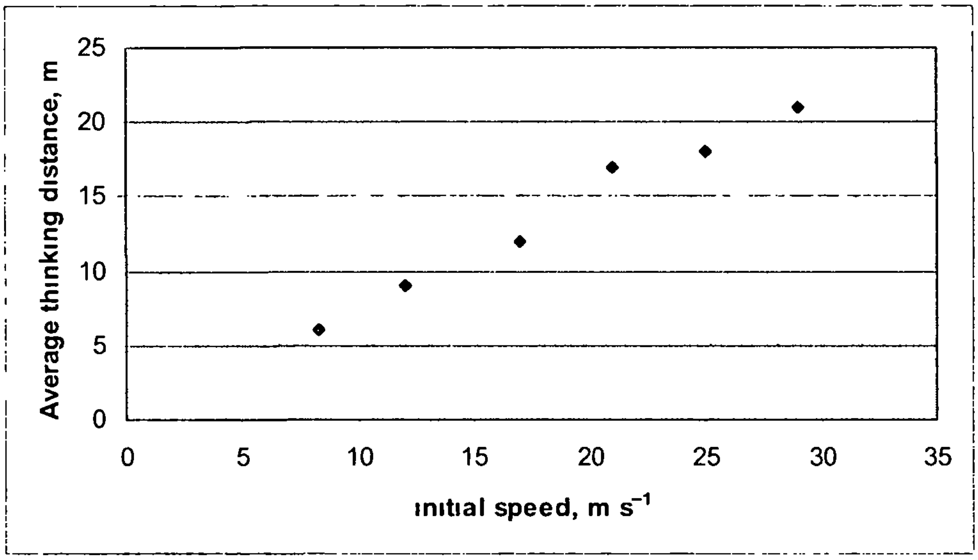
Question A7 (cont)

(b) Explain the following features of the experimental design in this investigation

[4 marks]

(i) The investigators decided that each driver should perform each trial five times	because
(ii) The investigators decided that each driver should perform the test at different speeds	because

The graph below shows the values of thinking distance plotted against initial speed



(c) (i) Draw a line of best fit (by eye) for the data shown in the graph

[2 marks]

(ii) Use the graph to determine an average value for the 'thinking time' required by the drivers to recognise the visual signal and react to it Show clearly how you worked out the time from the graph

[3 marks]

(d) Describe and explain the efforts that the investigators have made to reduce errors in this experiment

[4 marks]

(e) Write a conclusion for this experiment on the basis of the data gathered by the experimenters

[4 marks]

Question A8

The acceleration due to gravity on the Moon is 1 62 m s^{2} An astronaut on the Moon holds a hammer of mass 0 600 kg, at a height of 1 55 m above the Moon's surface

(a) Calculate the gravitational potential energy of the hammer when it is 1 55 m above the surface

[3 marks]

(b) The astronaut then lets the hammer fall What is the hammer's kinetic energy when it reaches the Moon's surface?

[2 marks]

(c) What is the hammer's speed when it reaches the Moon's surface?

[4 marks]

(d) After the hammer lands, it comes to rest on the surface What has happened to its energy?

[5 marks]

SECTION B–Optional section

Complete this section if you have studied **2A** as **ONE** of your latest pairs of Physics units

This section has **EIGHT (8)** questions Attempt **ALL** questions in the spaces provided

Allow approximately 60 minutes to complete this section *[66 marks]*

Question B1
A skydiver of mass is M travels vertically downwards for a distance x at a constant velocity u Taking the acceleration due to gravity to be g

(a) The net, or overall, force acting on the skydiver during this descent is

[2 marks]

(A) $2Mg$ downwards
(B) $2Mg$ upwards
(C) Mg downwards
(D) Mg upwards
(E) zero

(b) Which of the following best represents the skydiver's change in gravitational potential energy during this descent?

[2 marks]

(A) Mgx
(B) $2Mgx$
(C) $\frac{1}{2}Mu^2$
(D) Mu^2
(E) zero

Question B2

The radioisotope strontium-90, $^{90}_{38}\mathrm{Sr}$, is a beta emitter with a half-life of almost 30 years It is possible to sterilise medical dressings, simply by exposing them to the radiation from some strontium-90 If you did this, how long after exposure should you wait before using a sterilised dressing on a patient? Explain

[3 marks]

Question B3

The advertising for a car engine says that it is 28% efficient What does this mean?

[4 marks]

Question B4

If you ride a bicycle at full speed, which has the greater kinetic energy—you or the bicycle? Explain

[2 marks]

Question B5
Radium is an alpha emitter which decays as shown below

$$^{226}_{88}\text{Ra} \rightarrow {}^{222}_{86}\text{Rn} + {}^{4}_{2}\alpha$$

Using the data below, calculate the energy released in one such decay

mass of $^{4}_{2}\alpha$	4 002 60 u
mass of $^{222}_{86}\text{Rn}$	222 017 53 u
mass of $^{226}_{88}\text{Ra}$	226 025 36 u

Question B6

Mandy is a mouse, with a maximum acceleration of 0 25 m s^{-2}

Cliff is a cat who can accelerate at 0 40 m s^{2} when chasing a mouse

One day, Cliff and Mandy saw one another at the same moment Mandy immediately took off towards a hole in the wall, 2 5 m away While Mandy accelerated, Cliff took 1 0 seconds to start running He then accelerated directly toward the hole in the wall, 3 6 m away

(a) From the moment he took off, how long did Cliff take to run the 3 6 m to the wall?

[4 marks]

(b) How long did Mandy have to get away?

[2 marks]

(c) How far could Mandy travel in this time?

[4 marks]

Question B6 (cont.)

(d) Could Mandy reach the hole in the wall before Cliff arrived? Explain.

[2 marks]

(e) What is the formula for kinetic energy? What extra information would you need to determine Cliff's kinetic energy at the moment that he reached the wall? Explain.

[4 marks]

Question B7

Doctors may wish to diagnose or locate medical conditions such as circulatory problems, tumours or bone damage without using surgery For example, they can inject a radioisotope into a patient's bloodstream, and follow the radioactive source through the circulatory system This technique can also produce images of parts of a patient's body Technecium-99^{m}, a gamma emitter with a 6 00 hour half-life, is a suitable source

(a) Complete and balance the equation below representing the gamma decay of technecium-99^{m}

[2 marks]

$$^{99m}_{43}Tc \rightarrow$$

(b) If the original activity of a sample of technecium-99^{m} was 240 kBq, what would the activity be after 36-hours?

[4 marks]

____

____

____

____

(c) In the context of its use in medical imaging, suggest one advantage and one disadvantage of the length of the half-life of technecium-99^{m}

[4 marks]

One advantage ____

____

____

One disadvantage ____

____

____

(d) Using technecium-99^{m} to create an image poses a possible risk to a patient's health Explain the nature of this risk

[4 marks]

____

____

____

____

Question B8

A 1 000 kg rocket is at rest in outer space, far from any stars or planets It carries 600 kg of fuel

At a time t = 0 the mission controller switches on the rocket motor, burning fuel at a steady rate of 2 kg s^{-1} The rocket ejects the burnt fuel as a gas with a speed of 1 000 km s^{-1} (1 00 x 10^6 m s^{-1}) relative to the rocket

(a) Calculate the change in momentum of the fuel burnt in one second

[4 marks]

(b) Show that the force exerted by the exhaust gas on the rocket is equal to the rate of change of momentum of the gas

[4 marks]

The table below shows some details of the rocket and its subsequent motion Note that time t = 300 s is just before the mission controller turns off the motor

Time (s)	Mass of fuel consumed (kg)	Mass of rocket and remaining fuel (kg)	Thrust force (N)	Acceleration of rocket (m s^{-2})
0	0	1 600	2 00 x 10^6 N	1 250
100	200	1 400	2 00 x 10^6 N	1 430
200	400	1 200	2 00 x 10^6 N	1 670
300	600	1 000	2 00 x 10^6 N	2 000
400	600	1 000	0	0

Question B8 (cont)

(c) Describe how the rocket's velocity varies during the first 400 seconds of the rocket's motion Use the information from the table on the previous page to help you to work it out

[4 marks]

(d) On the axes below, sketch a graph which shows how the rocket's kinetic energy varies with time for the first 400 seconds of the rocket's motion

[4 marks]

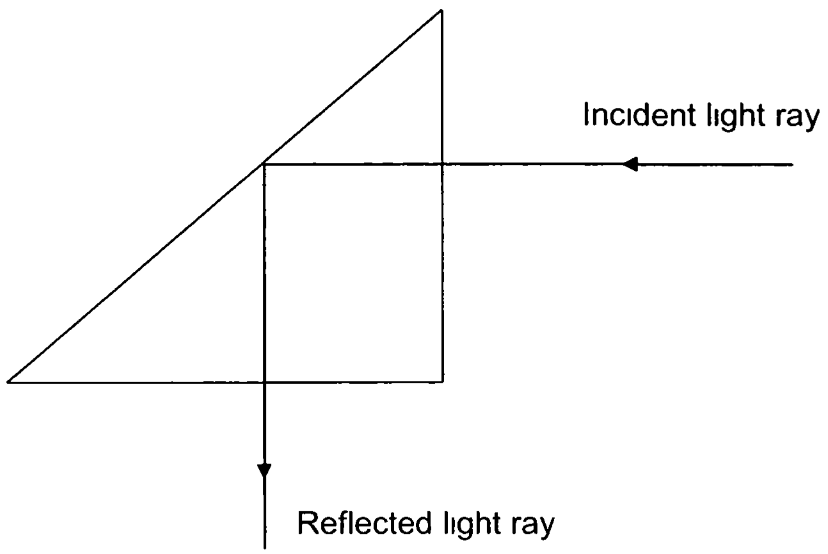
SECTION C–Optional section

Complete this section if you have studied **2B** as **ONE** of your latest pairs of Physics units

This section has **EIGHT (8)** questions Attempt **ALL** questions in the spaces provided

Allow approximately 60 minutes to complete this section *[66 marks]*

Question C1
A pair of binoculars contains prisms which change the direction of light rays by 90° The diagram below shows how this works

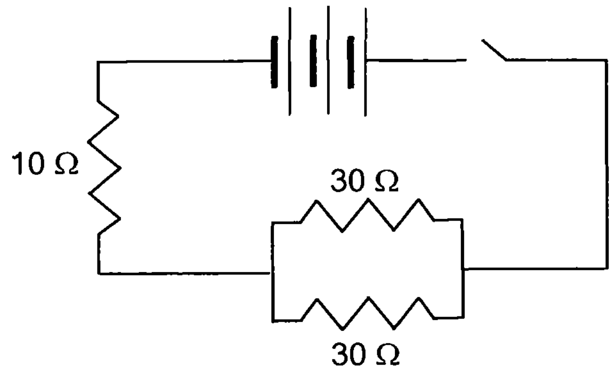


The prisms used are made of glass and have no silvering or mirror surfaces, yet they reflect light as well as any mirror Explain why this occurs

[4 marks]

Question C2

The diagram shows a part of the lighting circuit of a new motor vehicle Two 30 Ω tail lamps are arranged in parallel with each other, and in series with a 10 Ω indicator lamp



(a) What is the total or overall resistance of the pair of 30 Ω lamps when they are connected as shown?

[4 marks]

(b) What is the total or overall resistance of the circuit shown above?

[2 marks]

(c) What is one practical problem with the circuit as shown?

[2 marks]

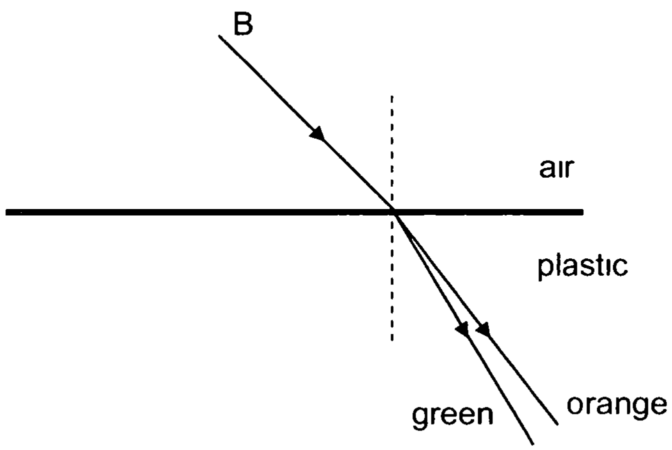
Question C3

A police 'speed trap' radar set emits and detects pulses of electromagnetic radiation in the microwave region of the spectrum Describe briefly how such a radar set might measure the speed of a motor vehicle

[4 marks]

Question C4

Julie set up an experiment as shown The light beam, (labelled B in the diagram) was a mixture of orange and green light When Julie shone the beam into a clear plastic block, she saw two coloured beams inside the plastic

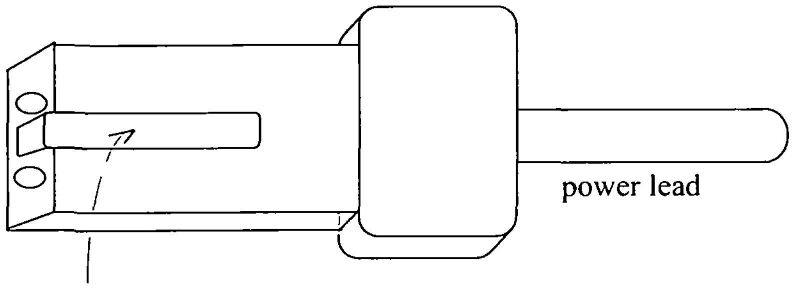


Comment on the speeds of orange and green light in air, and in the plastic

[4 marks]

Question C5

An electric jug may have a plug similar to the one shown in the diagram



If you take the plug or lead apart, you will find three wires, each with different coloured insulation, one wire is blue, one is brown, and one is green and yellow

(a) Which wire is connected to the external earthing strip?

[1 mark]

____

(b) How does the metal earthing strip work?

[3 marks]

____

____

____

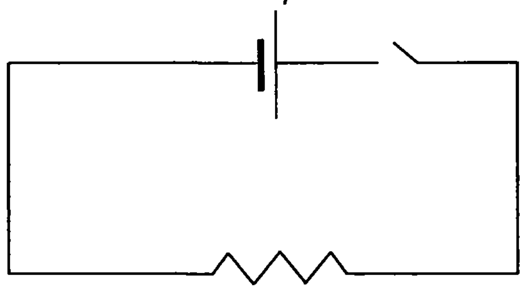
____

____

____

Question C6

The diagram below shows the main components of an electric torch



(a) Explain why a battery is essential in this circuit

[4 marks]

(b) In a particular torch, the light globe has a resistance of 20 Ω If the battery emf is 3.0 V, what is the current in the light globe?

[4 marks]

(c) Calculate the power at which the light globe operates, and hence how much energy the light globe uses when it operates for 10 minutes

[6 marks]

THIS PAGE HAS BEEN LEFT BLANK INTENTIONALLY

Question C7

An electric blanket contains two resistors, each 500 Ω The blanket is designed to work with a 250 V electricity supply Its controller switch has the following settings

OFF neither resistor connected to power supply
1 LOW
2 MEDIUM
3 HIGH

The possible arrangements of the resistors are
(i) only one resistor connected to the power supply
(ii) both resistors connected in parallel to the power supply
(iii) both resistors connected in series to the power supply

(a) Draw diagrams showing each of these circuits in the space below Label each circuit diagram clearly to identify which you have drawn

[6 marks]

(b) At the LOW setting, the current in the circuit is a minimum At the HIGH setting, the current is a maximum Determine which arrangement of resistors is best suited for the LOW setting, which is best suited for the MEDIUM setting, and which is best for the HIGH setting Explain your reasoning in each case

[12 marks]

Arrangement (i) is best suited to the ______________________ setting

because ____

____

____

____

____

____

____

Question C7 (cont.)

Arrangement (ii) is best suited to the ______________________________ setting

because ____

____

____

____

____

____

____

Arrangement (iii) is best suited to the ______________________________ setting

because ____

____

____

____

____

____

____

Question C8

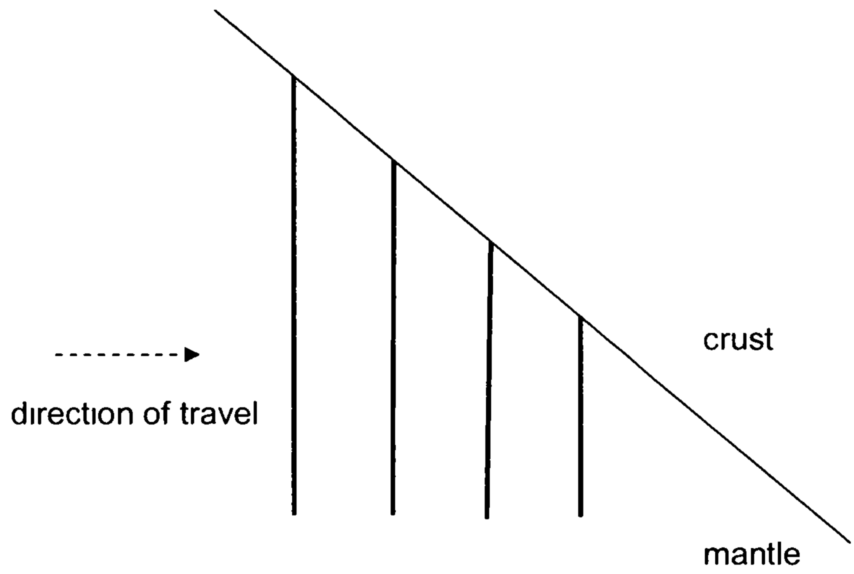
An earthquake creates a series of waves which travel through the Earth at high speeds Longitudinal earthquake waves, known as P waves, pass through granite rock in the Earth's crust at 5 5 km s ^{1}

(a) If the wavelength of a P wave passing through granite is 700 metres, what is the wave frequency?

[4 marks]

(b) The speed of P waves in the Earth's mantle is higher than their speed in the crust Complete the diagram below which shows a series of P waves reaching the boundary between the mantle and the crust

[4 marks]



(c) Briefly describe TWO features of P waves which would change as the waves cross the boundary between the mantle and the crust, and TWO features which would not change

[4 marks]

Features which change	Features which do not change

SECTION D–Optional section

Complete this section if you have studied **3A** as **ONE** of your latest pairs of Physics units

This section has **EIGHT (8)** questions Attempt **ALL** questions in the spaces provided

Allow approximately 60 minutes to complete this section *[66 marks]*

Question D1
Two children sit on opposite ends of a see-saw **Estimate** the torque exerted by one of the children about the pivot point of the see-saw

[4 marks]

For copyright reasons the graphic of children on a see-saw cannot be reproduced in the online version of this document

(Miami-Dade County Public Schools, n d)

Question D2
A transformer has 200 turns in the primary coil An AC signal of 120 V is applied If the output coil has 600 turns what is the secondary voltage?

[4 marks]

Question D3

A charge is *moving* through the vacuum of deep space The magnetic field in the region surrounding the charge is zero

Is this statement true or false? Give a reason for your answer

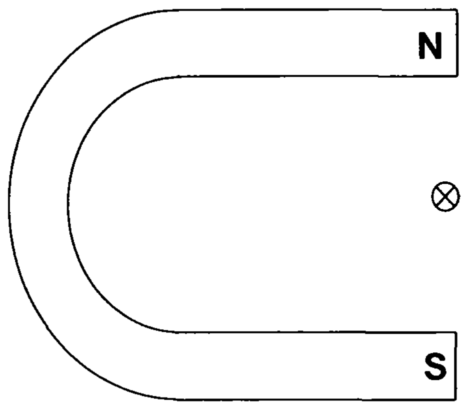
[4 marks]

Question D4

A wire carrying an electric current is placed between the poles of a horseshoe magnet The current is going into the page

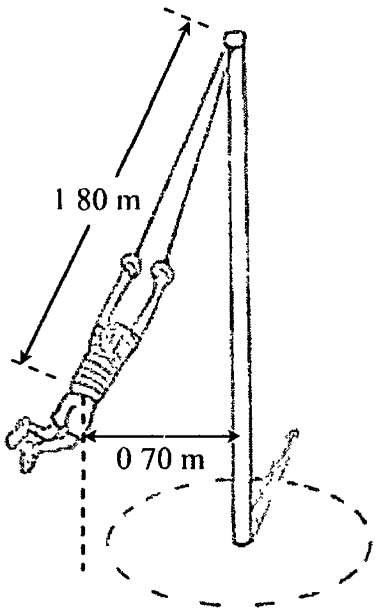
Show on the diagram the direction of the force on the wire

[2 marks]



Question D5

A 20 0 kg child is shown swinging freely around a playground maypole such that his centre of mass is always located 1 80 m from the top of the pole and 0 70 m horizontally away from the pole



On the diagram at right, clearly show and label the sizes and directions of any forces acting on the child

[6 marks]

Question D6

A bicycle has an electric generator attached to the rear wheel to provide power for a headlamp The barrel of the generator rubs against the bicycle wheel, which causes it to rotate Inside the generator there are 400 turns of wire forming a coil with an average area of 140 mm^2 The coil rotates between the poles of a permanent magnet

When the bicycle is ridden at 1 5 m s^{-1} the generator is rotating at 83 3 revolutions per second and generates a voltage of 4 4 V AC across the lamp, whose resistance is 1 1 Ω

(a) (i) What is the frequency of the AC voltage generated?

[2 marks]

(ii) What power is provided to the lamp?

[3 marks]

(b) Calculate the approximate magnetic field strength passing through the coil

[4 marks]

Question D6 (cont)

(c) With the aid of a diagram, explain how a commutator could be used to change the output of the generator from AC to DC

[4 marks]

Question D7

Playing a hard game of tennis, Pat Strafer hits a ball at an angle of 1 5° above the horizontal at a speed of 55 m s^{-1} At the instant he hits it, the ball is 0 35 m above the ground

(a) (i) Sketch the trajectory (path) of the ball from the racquet to the ground, without air resistance

[2 marks]

(ii) On the same sketch, show how air resistance will affect this trajectory Label your sketch clearly

[1 mark]

(iii) Explain why air resistance has this effect

[2 marks]

____

____

____

____

(iv) Is there any time at which the ball will have zero acceleration between the time it is hit and the time it reaches the ground? Give a reason for your answer

[3 marks]

____

____

____

____

____

____

____

Question D7 (cont.)
(b) Ignoring air resistance

(i) Find the time the ball is in the air from the moment it is hit to the time it reaches the ground

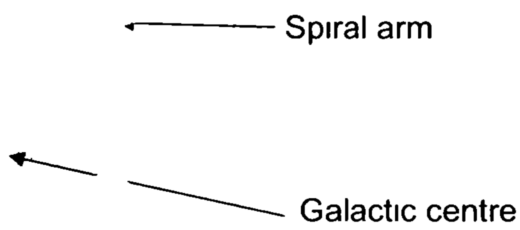
[4 marks]

(ii) Find the horizontal distance travelled in this time

[3 marks]

Question D8

Most people are aware that the Earth revolves around the Sun in a nearly-circular orbit that takes 365¼ Earth days to complete The other planets in the solar system follow generally similar orbits Each planet has its own unique orbital radius, and hence each planet has a unique orbital period All the members of our solar system, even the most distant, follow these orbits because of the constant tug of the Sun's gravitational field Our Sun also follows an orbit Located in a spiral arm that branches out from the centre of our Milky Way galaxy, it moves with a tangential speed of 250 km s^{-1} relative to the galactic centre, 30 000 light years away One light year is the distance that light travels through vacuum in one Earth year By comparison, the Earth is about eight light minutes from the Sun



The Milky Way galaxy contains a large number of stars, most of which are arranged in a sphere-shaped volume around the galactic centre Only a small fraction of the total exist (perhaps 10%), like our own Sun, in the spiral arms Some stars have more mass than the Sun, but others have less mass Many have a similar mass to the Sun, which at 2×10^{30} kg is a middle-sized star

The great gulfs between the stars are not completely empty Thin clouds of gas and dust swirl in this space, absorbing and reflecting starlight There is so much of this interstellar gas and dust that we on Earth cannot see the stars at the galaxy's centre, almost all of the stars in our galaxy are obscured by dust While remarkably effective at blocking out light, these clouds of gas and dust have negligible mass compared to the stars that they hide In some regions these gas clouds are unusually thick Such regions are places where new stars are igniting their nuclear fires for the first time

(a) How far away, in metres, is the galactic centre?

[2 marks]

____

____

____

(b) What is the centripetal acceleration of the Sun around the galactic centre?

[3 marks]

____

____

____

Question D8 (cont)

(c) Calculate the orbital period of the Sun around the centre of the Milky Way galaxy

[3 marks]

(d) What mass of stars exists at the galactic centre?

[5 marks]

(e) **Estimate** how many stars such as our Sun there are in the Milky Way galaxy State clearly any assumptions you make

[5 marks]

SECTION E–Optional section

Complete this section if you have studied **3B** as **ONE** of your latest pairs of Physics units

This section has **EIGHT (8)** questions Attempt **ALL** questions in the spaces provided

Allow approximately 60 minutes to complete this section *[66 marks]*

Question E1

What are the dual properties of light? For EACH of these two properties, give ONE example where it is exhibited by light

[4 marks]

Question E2

Briefly outline one piece of evidence that supports the Big Bang theory

[4 marks]

Question E3
Astronomers believe that quasars are exceptionally luminous but are very far away, rather than less bright but close The evidence for this is the large red shifts associated with the light emitted by quasars Explain why this suggests they are very distant

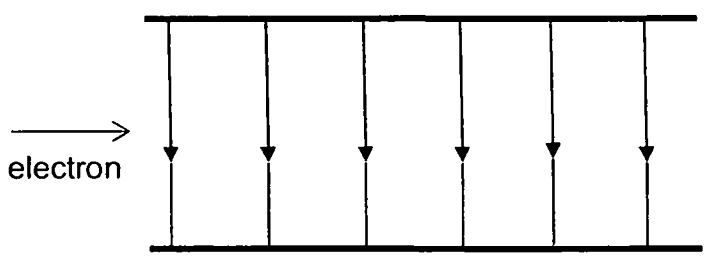
[4 marks]

Question E4
In a scanning electron microscope, each electron is accelerated to a kinetic energy around 3 5 keV Determine the de Broglie wavelength of such an electron

[6 marks]

Question E5
Complete the diagram below, showing the path of the electron after it enters the electric field shown

[2 marks]

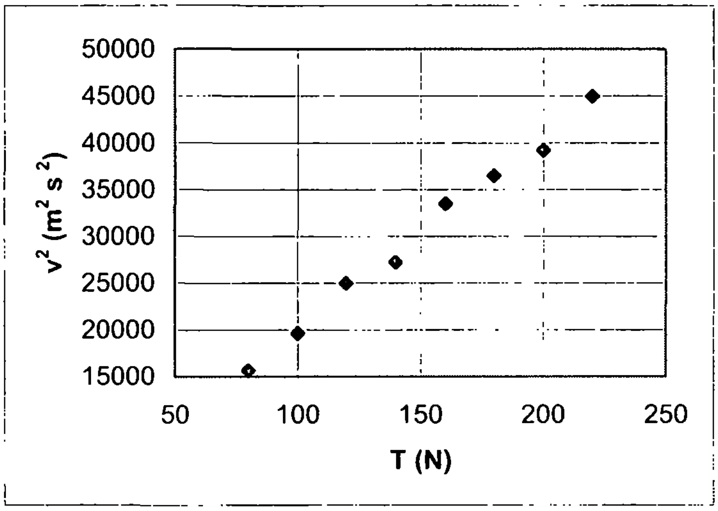


Question E6

Geraldine was investigating the speed of waves along stretched strings She generated these waves by plucking a 0 760 m length of guitar string She knew the speed was given by

$$v = \sqrt{\frac{T}{\mu}}$$

Where T is the tension in the string and μ is the mass per unit length She plotted her results in the graph below



(a) (i) Why did Geraldine plot v^2 against T and not just v against T?

[2 marks]

(ii) What are the units of μ?

[2 marks]

Question E6 (cont)

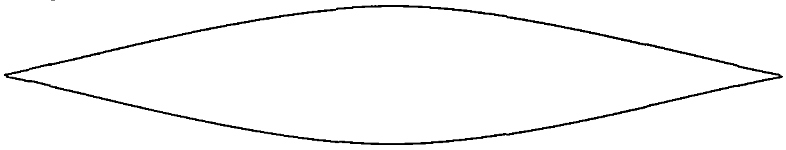
(b) Use the graph to determine the best experimental value of μ for this string Show your working clearly

[5 marks]

(c) Geraldine adjusted the tension to 125 N What is the frequency of the fundamental mode of the string now? Show how you obtain the figures you use

[4 marks]

(d) The wave envelope of the string when it is oscillating in its fundamental mode is shown in the diagram below



(i) Sketch the wave envelope when the string is oscillating in its second overtone (also called the third harmonic)

[2 marks]

Question E6 (cont.)

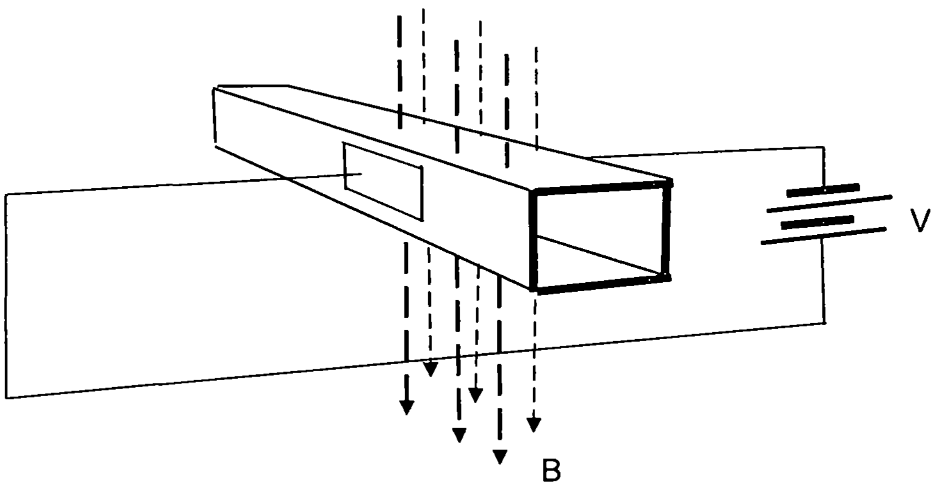
(ii) The wave in the string is a transverse wave but sound is a longitudinal wave. How is it possible for a transverse wave to produce sound?

[3 marks]

Question E7

An electromagnetic pump is a device which can pump solutions containing positively and negatively charged particles through non-metallic tubes Blood is one example of such a solution

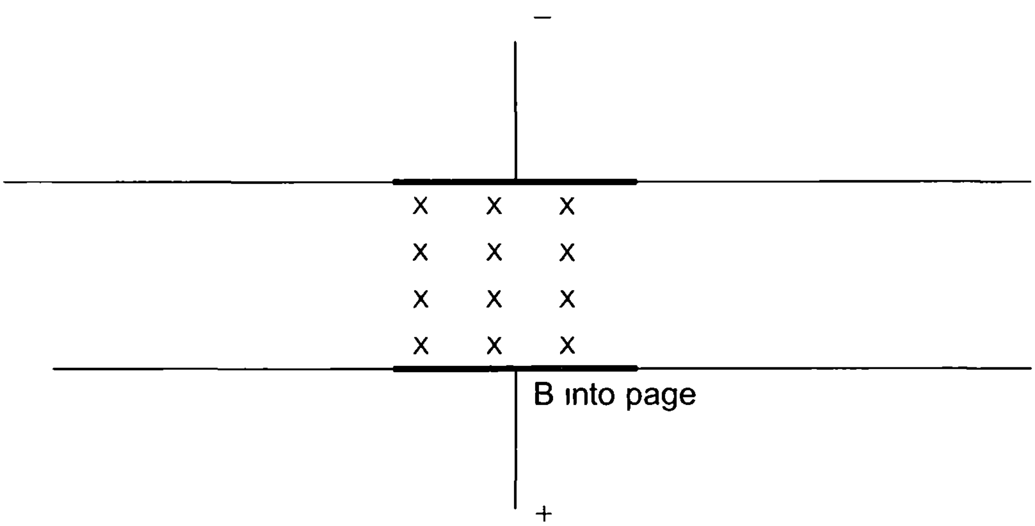
The principle on which an electromagnetic pump operates is shown in the diagram below For convenience, the tube is shown as having a rectangular cross-section



Two metal plates are placed on opposite sides of the tube, and a potential V is applied between them so that the charged particles in the liquid begin to flow across the tube At the same time, a magnetic field B is applied at right angles to the electric field produced by the plates

(a) Indicate on the diagram below the motion of the positively charged particles in the solution (You are looking down on the tube in the above diagram, that is, you are looking in the direction of the magnetic field B)

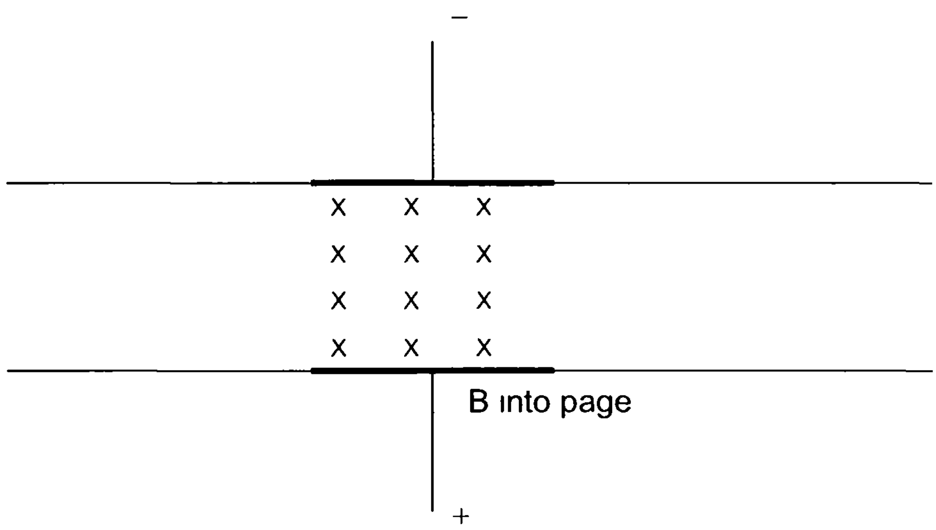
[2 marks]



Question E7 (cont)

(b) Indicate on the diagram below the motion of the negatively charged particles in the solution (You are again looking down on the tube in the above diagram, that is, you are looking in the direction of the magnetic field *B*)

[2 marks]



(c) Briefly describe how this type of pump works

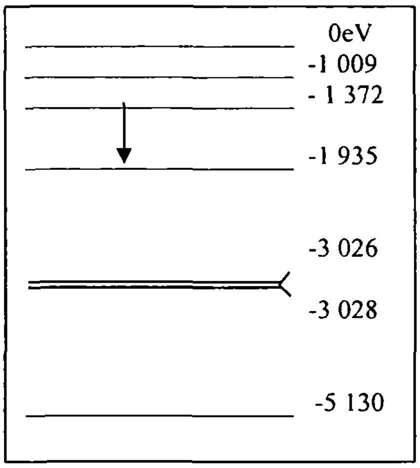
[7 marks]

(d) Describe the energy transfer processes involved as the pump operates

[4 marks]

Question E8

(a) The diagram shows some of the energy levels of sodium (*Only the lowest energy level shown is occupied by an electron when the atom is in its ground state)*



(i) What is the minimum energy of a photon that can ionise a sodium atom?

Answer ____________ eV

[1 mark]

(ii) What process does the arrow drawn in the diagram represent? What is the result of the process?

[3 marks]

____

____

____

____

(b) (i) Two lines in the sodium spectrum resulting from electron transitions to the ground state in the yellow region are very close together Explain how this light is produced Hence estimate the wavelength of yellow light

[3 marks]

____

____

____

____

(ii) Identify on the diagram a transition which will cause the emission of a photon with a wavelength longer than for yellow light State the reason you selected this transition

[2 marks]

____

____

____

____

Question E8 (cont)

(c) Explain how the spectrum of light from a star can be used to identify elements in the star

[4 marks]

____

____

____

____

END OF PAPER

This blank space has been provided for additional workings

ACKNOWLEDGEMENTS

SECTION D

Question D1 Miami-Dade County Public Schools (n d) [Graphic of seesaw] Retrieved July 27, 2002, from http //www dade k12 fl us/wachapman/graphics/seesaw/gif

Published by the Curriculum Council of Western Australia
27 Walters Drive
OSBORNE PARK WA 6017

EXAM MARKING KEY

1/ 534_3 DOC

PHYSICS
SECTION A–Compulsory section

Question A1a
Wave period
A1a
(Outcome 2)

Mark	Solution	Notional level
1	Period = 37 s	4

Question A1b
Wave frequency
(Outcome 2)

Mark	Solution	Notional level
1	$frequency = \dfrac{1}{period}$	5
1	$= \dfrac{1}{37}\ s^{-1} = 0.027\ Hz$	5

Question A1c
Number of waves
(Outcome 2)

Mark	Solution	Notional level
1	period = 37 s 5.0 min = 300 s	5
1	n° waves $= \dfrac{300}{37} = 8.1$	6

Question A2a
Light speed
(Outcome 2)

Mark	Solution	Notional level
1	$c = f\lambda$	5
1	$= (4.3 \times 10^{14})(4.7 \times 10^{-7})$	5
1	$= 2.02 \times 10^{8}\ m\ s^{-1}$	5

Question A2b
Light speed
(Outcome 2)

Mark	Solution	Notional level
1	B approximately the same as the speed of red light	4

Question A3a
Displacement calculation
(Outcome 3)

Mark	Solution	Notional level
1	Let north be positive Then displacement = +40 + (-50) = -10 m	5
1	Displacement = 10 0 m south	5

Question A3b
Average speed calculation
(Outcome 3)

Mark	Solution	Notional level
1	$\text{speed} = \frac{\text{distance}}{\text{time}}$	5
1	$= \frac{90}{15\ 6}\ \text{m s}^{-1}$	5
1	$= 5\ 77\ \text{m s}^{-1}$	5

Question A4
Force calculation
(Outcome 3)

Mark	Solution	Notional level
1	$F = ma$	5
1	$= (1500\ \text{kg})(2\ 75\ \text{m s}^{-2})$	5
1	$= 4\ 12 \times 10^{3}\ \text{N}$	5

Question A5
Current calculation
(Outcome 2)

Mark	Solution	Notional level
1	$P = VI$	5
1	$I = \frac{P}{V}$	6
1	$I = \frac{250}{60}\ \text{A}$ $I = 4\ 2\ \text{A}$	6

Question A6a
Current from graph
(Outcome 1)

Mark	Solution	Notional level
2	Current at 3 0 V = 1 6 A	4

Question A6b
Resistance calculation from graph
(Outcomes 1 & 3)

Mark	Solution	Notional level
1	$V = IR$	5
1	$R = \frac{V}{I}$	6
1	R = gradient of the graph $R = \frac{\text{rise}}{\text{run}}$	6
1	$R = \frac{(6-0)}{(3\ 3-0)}\Omega$ $R = 1\ 82\,\Omega$	6

Question A6c
Power calculation from graph
(Outcomes 1 & 2)

Mark	Solution	Notional level
1	P = VI	5
1	P = area under the curve	7
1	P = ½(base)(height)	7
1	P = ½(2 1)(4 0) W P = 4 2 W	7

Question A6d
Energy
(Outcomes 1 & 2)

Mark	Solution	Notional level
1	E = VIt	6
1	E = (area under curve)(time)	7
1	E = (½)(2 5)(4 7)(20) J	7
1	E = 118 J	7

Question A7a
Variables considered
(Outcome 1)

Mark	Solution	Notional level
1	They measured thinking time OR braking distance	4
2	They controlled [any two of] type of vehicle, daylight, condition of road, stimulus	4

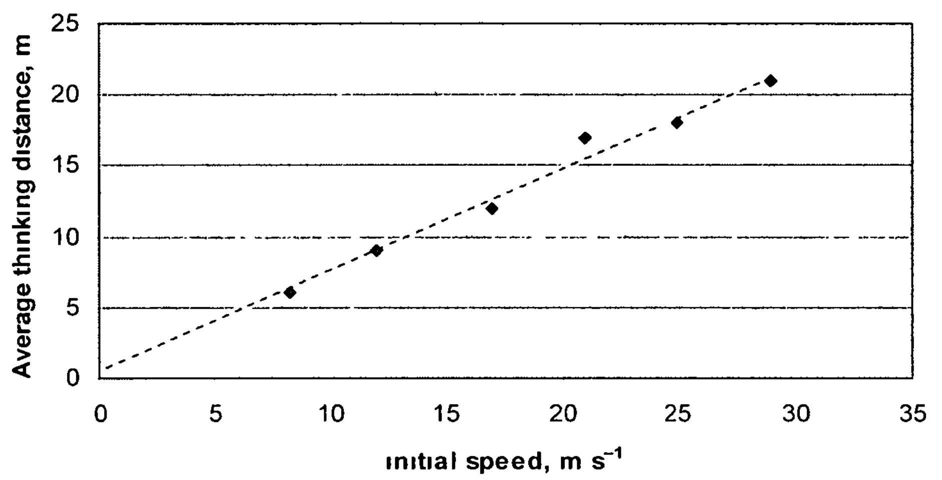
Question A7b(i)
Experimental design
(Outcome 1)

Mark	Solution	Notional level
1	This would reduce the uncertainty in their measurements	5
1	By averaging out human errors by any one driver	5

Question A7b(ii)
Experimental design
(Outcome 1)

Mark	Solution	Notional level
1	Having trials for each driver at each speed reduces possible errors/uncertainties	5
1	By allowing for people applying the brakes differently at different speeds (and so biasing the data)	5

Question A7c(i)
Line of best fit
(Outcome 1)

Mark	Solution	Notional level
2	If LOBF as shown, with comment about the outlier 	8
	OR If outlier disregarded without comment, 1 mark only	6

Question A7c(ii)
Thinking time calculation
(Outcomes 1 and 3)

Mark	Solution	Notional level
1	$v = \frac{s}{t}$	5
1	$t = \frac{s}{v} = \frac{rise}{run} = \text{gradient}$	6
1	$t = \frac{(20-1)}{(27-0)} = \frac{19}{27}\,s$ $t = 0.70\ s$	6

Question A7d
Error reduction
(Outcome 1)

Mark	Solution 2 marks (1 describe, 1 explain) for *each* of two reasons, such as they	Notional level
4	Used electronic timing and distance recording to remove the human element Averaged values of measurements to even out variations in the data, Used many drivers to reduce any variations due to individual differences	6

OR

2	Reproducing the answer in (b) (i) and (b) (ii)—maximum mark 2	5

Question A7e
Conclusion
(Outcome 1)

Mark	Solution	Notional level
4	For full marks, responses should make specific recommendations as below, and also comment on the limitations of the study such as the reliance on one vehicle type or confining the study to particular weather and road conditions	8

OR

Mark	Solution Responses may make specific recommendations, such as	Notional level
3	Reducing car speed to 30 km h^{-1} in areas where there are many pedestrians may reduce the stopping distance enough to make road crossing safe	7

OR

Mark	Solution Responses may make general recommendations such as	Notional level
2	Reducing speed reduces the stopping distance, saving lives of pedestrians	6

OR

Mark	Solution Responses may summarise the data, such as	Notional level
1	Stopping distance gets bigger as the speed of the car increases or Thinking time is consistent between drivers and at any speed	5

Question A8a
Gravitational potential energy calculation
(Outcome 2)

Mark	Solution	Notional level
1	$E_p = mgh$	5
1	$E_p = (0\ 600)(1\ 62)(1\ 55)$ J	5
1	$E_p = 1\ 51$ J	5

Question A8b
Kinetic energy
(Outcome 2)

Mark	Solution	Notional level
1	In the absence of friction, the hammer's gravitational potential energy becomes kinetic energy	6
1	Hence the final value of kinetic energy is 1 51 J	6

Question A8c
Final speed calculation
(Outcome 2 OR 3)

Mark	Solution This can be solved in several ways, e g using equations of rectilinear motion, or using conservation of energy	Notional level
1	$v^2 = u^2 + 2as$	5
1	$v^2 = 0 + 2(1\ 62)(1\ 55)$	5
1	$v = \sqrt{5\ 022}\ m\ s^{-1}$	6
1	$v = 2\ 24\ m\ s^{-1}$	6

Question A8d
What happens to the energy
(Outcome 2)

Mark	Solution *Response may look to the future fate of the energy, such as*	Notional level
5	It becomes heat/internal energy in the hammer and the Moon surface, increasing the temperature of both This will eventually spread out and become undetectable	8

OR

Mark	Solution *Response may look to a detailed distribution of the energy, such as*	Notional level
5	It becomes heat/internal energy in the hammer and the Moon surface increasing the temperature of both Some will be transferred to dust and pebbles as kinetic energy, making a splash on the surface, or may travel through the rock as a shock wave	8

OR

Mark	Solution *Response may be a specific answer such as*	Notional level
4	It becomes heat/internal energy in the hammer and the Moon surface, increasing the temperature of both	7

OR

Mark	Solution *Response may be a general answer such as*	Notional level
3	It becomes heat/internal energy in the hammer and the Moon surface	6

OR

Mark	Solution *Response may be a vague answer such as*	Notional level
2	Heat or internal energy	5

SECTION B–Optional section

Question B1a
Overall force
(Outcome 3)

Mark	Solution	Notional level
2	E zero	5

Question B1b
Energy change
(Outcome 2)

Mark	Solution	Notional level
2	A *Mgx*	5

Question B2
Beta effects
(Outcomes 2 & 3)

Mark	Solution	Notional level
1	Beta radiation ionises whatever it hits	5
2	but such ionisation does not make the target radioactive The bandage is immediately useable	6

Question B3
Efficiency
(Outcome 2)

Mark	Solution	Notional level
2	28% of the power output [or energy output] of the engine is useful	6
2	The rest is wasted' as heat without being available for acceleration or maintaining speed	6

Question B4
Kinetic energy difference
(Outcome 2)

Mark	Solution	Notional level
2	Both are at the same speed, so any kinetic energy difference comes from a difference in mass	5
2	The bicycle is significantly less massive than the rider, so the rider has the greater kinetic energy	5

Question B5
Energy from decay
(Outcome 2)

Mark	Solution	Notional level
2	mass LHS = 226 02536 u mass RHS = (222 01753 + 4 00260) u = 226 02013 u	5
1	mass difference = (226 02536 - 226 02013) u = 0 00523 u	6
2	energy released = (0 00523 u) x (931 5 MeV u^{1}) = 4 87 MeV	6

Question B6a
Cat run time
(Outcome 3)

Mark	Solution	Notional level
1	$s = ut + \frac{1}{2}at^2$	5
1	$t^2 = \frac{2s}{a}$	6
1	$t^2 = \frac{2 \times 3\ 6}{0\ 4} s^2$	6
1	$t = 4\ 24$ s	6

Question B6b
Mouse escape time
(Outcome 3)

Mark	Solution	Notional level
1	It took Cliff 1 00 s to get started	4
1	so Mandy had (4 24 + 1 00) = 5 24 s to get away	5

Question B6c
Mouse escape distance
(Outcome 3)

Mark	Solution	Notional level
1	$s = ut + \frac{1}{2}at^2$	5
2	$s = 0 + \frac{1}{2} \times 0\ 25 \times 5\ 24^2$	5
1	$s = 3\ 44$ m	5

Question B6d
Mouse escape
(Outcome 3)

Mark	Solution	Notional level
1	Mandy only had to run 2 5 m	4
1	But she had time to run over 3 m, so she got away	4

Question B6e
Kinetic energy
(Outcome 2)

Mark	Solution	Notional level
1	Kinetic energy is $\frac{1}{2}mv^2$	5
2	so have to know Cliff's final velocity/speed	5
1	and his mass	5

Question B7a
Equation
(Outcome 2)

Mark	Solution	Notional level
2	${}^{99m}_{43}Tc \rightarrow {}^{99}_{43}Tc + \gamma$	5

Question B7b
Activity
(Outcome 3)

Mark	Solution	Notional level
1	36 hours is 6 half-lives i e n = 6	5
1	$\frac{1}{2^n} = \frac{A}{A_0}$ $\frac{1}{2^6} = \frac{A}{240}$	5
1	$A = \frac{240}{2^6}$ kBq	6
1	$A = 3\ 75$ kBq	6

Question B7c
Half life
(Outcome 1)

Mark	Solution	Notional level
2	One advantage The radioactivity will be all gone in a short time, so minimising risk of long-term damage to the patient	5
2	One disadvantage significant amounts of the radioisotope will decay during transport and storage	5

Question B7d
Risk of radiation
(Outcome 1)

Mark	Solution	Notional level
2	Gamma radiation can ionise molecules	5
2	This can kill cells or cause mutations	5

Question B8a
Change in momentum
(Outcome 3)

Mark	Solution	Notional level
1	$\Delta p = mv - mu$	5
1	$\Delta p = (2\ )(1000000 - 0)\ \text{kg m s}^{1}$	5
1	$\Delta p = 2\ \text{x}10^6\ \text{kg m s}^{1}$	6
1	The direction of the momentum change is in the direction that the exhaust gas travels	6

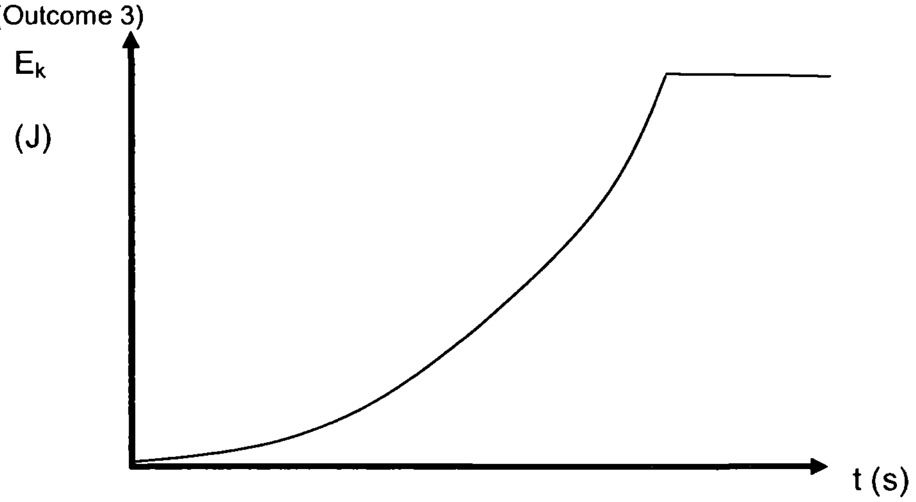
Question B8b
Rate of change in momentum
(Outcome 3)

Mark	Solution	Notional level
1	$\Delta p = mv - mu$	5
1	Rate means 'divided by time' so $\dfrac{\Delta p}{t} = \dfrac{mv - mu}{t}$	6
1	$\dfrac{\Delta p}{t} = m\dfrac{v-u}{t}$ $\dfrac{\Delta p}{t} = ma$ Hence $\dfrac{\Delta p}{t} = F$	7
1	Newton's 3rd law $F_{\text{rocket on gas}} = F_{\text{gas on rocket}}$	7

Question B8c
Variation in velocity
(Outcome 3)

Mark	Solution	Notional level
1	The rocket accelerates for the first 300 seconds its velocity increases	4
1	The acceleration is not uniform because the rocket's mass decreases while the thrust stays the same	5
1	Thus the acceleration increases until t = 300 s	6
1	At t = 300 s the motor stops and the rocket keeps going in a straight line at whatever its final velocity was	6

Question B8d
Variation in kinetic energy
(Outcome 3)



Mark	Solution	Notional level
1	Axes labelled	5
1	Curve starts at origin	6
1	Upward curve	7
1	Kinetic energy constant after 300 s	7

SECTION C–Optional section

Question C1
Total internal reflection
(Outcome 3)

Mark	Solution	Notional level
1	Light enters the prism along a normal, no change in direction	5
2	At the glass-air interface, angle of incidence > critical angle	6
1	Hence there is total internal reflection at this surface	6

Question C2a
Parallel resistance
(Outcome 3)

Mark	Solution	Notional level
1	The lamps are in parallel, so $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$	5
1	$\frac{1}{R_T} = \frac{1}{30} + \frac{1}{30}$ $\frac{1}{R_T} = \frac{1}{15}$ $R_T = 15\,\Omega$	6

Question C2b
Combination resistance
(Outcome 3)

Mark	Solution	Notional level
1	The 30 Ω pair is in series with the 10 Ω lamp, so $R_T = R_1 + R_2$	5
1	$R_T = (10 + 15)\,\Omega = 25\,\Omega$	5

Question C2c
Practical problem with circuit
(Outcome 3)

Mark	Solution	Notional level
2	If the 10 Ω lamp blows the others cannot work OR The indicator and the tail lights must be on at the same time	5

Question C3
How a radar works
(Outcome 3)

Mark	Solution	Notional level
1	Emit a pulse at a known time	5
1	Detect a reflection from a vehicle at a later time	5
1	Time difference allows the position (distance) to be worked out	6
1	Two such determinations allow the speed to be worked out	6

OR

Mark	Solution	Notional level
1	Emit a pulse of known frequency	5
2	Detect and measure the frequency of a reflection from a vehicle	6
1	Frequency difference allows the speed to be worked out	6

Question C4
Dispersion
(Outcome 2)

Mark	Solution	Notional level
2 OR 1	Orange and green have almost the same speed in air OR Orange and green have the same speed in air	5 OR 4
1	The speeds are slower in plastic than in air	6
1	Green is slower than orange in plastic (and air)	7

Question C5a
Earthing
(Outcome 1)

Mark	Solution	Notional level
1	The yellow & green wire	4

Question C5b
How earthing works
(Outcomes 1 and 3)

Mark	Solution	Notional level
1	The earthing strip is connected to the metal case or frame of the jug	5
1	The strip also connects to the Earth	5
1	If the metal case becomes 'live' a large current runs to Earth, blowing a fuse	6

Question C6a
Role of battery
(Outcomes 1 & 2)

Mark	Solution	Notional level
1	A battery creates an emf or voltage	4
1	This means that the battery provides the charges with potential energy	5
1	Without this potential energy, charges could not flow around the circuit	5
1	The battery is thus the source of the energy transferred into the resistor when the current flows	6

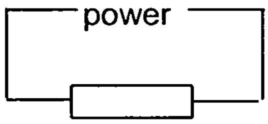
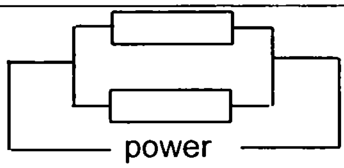
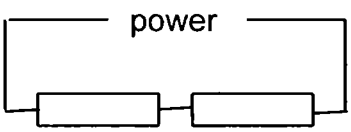
Question C6b
Current
(Outcome 3)

Mark	Solution	Notional level
1	$V = IR$	5
1	$I = \frac{V}{R}$	6
1	$I = \frac{3}{20}$ A	6
1	$I = 0.15$ A or 150 mA	6

Question C6c
Power
(Outcome 2)

Mark	Solution	Notional level
1	$P = VI$	5
1	$P = 3 \times 0.15$ W	6
1	$P = 0.45$ W	6
1	$P = \frac{E}{t}$	5
1	$E = Pt$	7
1	$E = 0.45$ W $\times (10 \times 60)$ s $E = 270$ J	7

Question C7a
Circuit diagrams
(Outcome 3)

Mark	Solution [2 marks each if circuit shown, 1 mark each if only resistors shown]	Notional level
2	 (i)	5
2	 (ii)	5
2	 (iii)	5

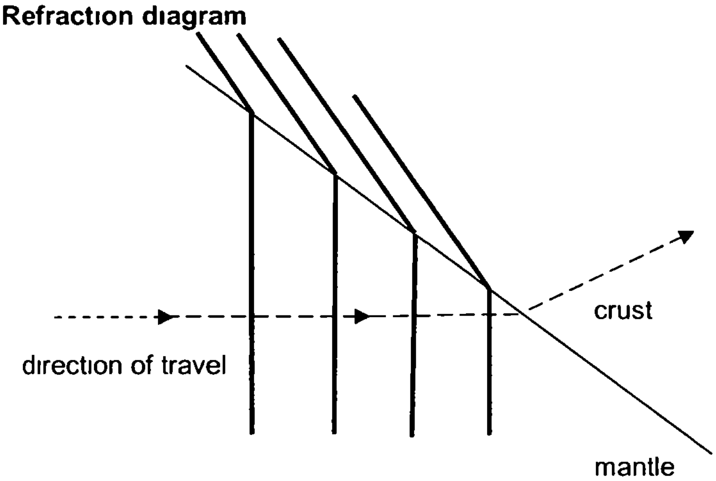
Question C7b
Arrangement of resistors
(Outcome 2)

Mark	Solution	Notional level
1	Arrangement (i) is best suited to the MEDIUM setting	7
1	because this gives a medium resistance	5
1	and thus a medium current at the full 250 V	6
1	power = VI so this gives a medium power setting	7
1	Arrangement (ii) is best suited to the HIGH setting	7
1	because this gives the lowest resistance	5
1	and thus the highest current at the full 250 V	6
1	power = VI so this gives the highest power setting	7
1	Arrangement (iii) is best suited to the LOW setting	7
1	because this gives the highest resistance	5
1	and thus the lowest current at only 125 V	6
1	power = VI so this gives the lowest power setting	7

Question C8a
Wave frequency
(Outcome 3)

Mark	Solution	Notional level
1	$v = f\lambda$	5
1	$f = \frac{v}{\lambda}$	6
1	$f = \frac{5500\ \mathrm{m\ s^{-1}}}{700\ \mathrm{m}}$	6
1	$f = 7.86\ \mathrm{Hz}$	6

Question C8b
Refraction diagram



(Outcome 3)

Mark	Solution	Notional level
2	Refraction toward normal	5
2	Refracted wavefronts	6

Question C8c
Wave features
(Outcomes 2 and 3)

Mark	Solution	Notional level
2	Features which change [any 2, 1 mark each] • Speed is dependent on the medium • Wavelength changes when speed changes • Amplitude may change with the medium	5 6
2	Features which do not change [any 2, 1 mark each] • Frequency depends on the source • Period depends on frequency • Phase does not change on refraction	5 6

SECTION D– Optional Section

Question D1
Torque estimate
(Outcome 3)

Mark	Solution	Notional level
1	Estimate of moment arm (0 5-3 m)	5
1	Estimate of child's mass (5-50 kg) or child s weight (50-500 N)	5
1	$\tau = rF$	5
1	from $\tau = 0\ 5\ \times 50 = 25\ \text{m N}$ to $\tau = 3\ \times 500 = 1500\ \text{m N}$	5

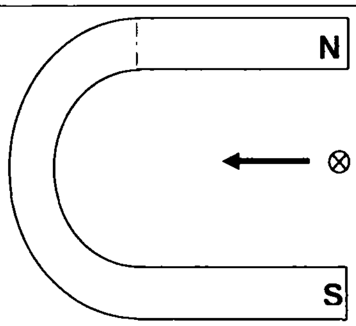
Question D2
Secondary potential
(Outcome 2)

Mark	Solution	Notional level
1	$\frac{N_p}{N_s} = \frac{V_p}{V_s}$	5
1	$V_s = \frac{N_s \times V_p}{N_p}$	6
1	$V_s = \frac{600 \times 120}{200}\ V$	6
1	$V_s = 360\ V$	6

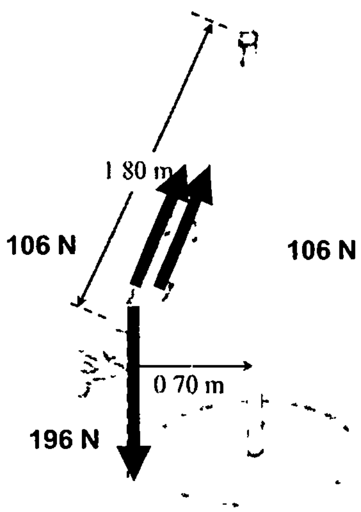
Question D3
Magnetic field around moving charge
(Outcome 3)

Mark	Solution	Notional level
2	Moving charges create magnetic fields	5
2	The statement is therefore false	6

Question D4
Direction of magnetic force
(Outcome 3)

Mark	Solution	Notional level
2		5

Question D5
Forces
(Outcome 3)

Mark	Solution	Notional level
1	weight force $= mg = 20x9\ 8 = 196\ \mathrm{N}$	6
1	Angle between pole and chains $\sin\theta = \dfrac{0\ 7}{1\ 8}$ $\theta = 22\ 89°$	6
1	Tension in each chain has vertical component = half the child's weight $T_v = \dfrac{T\cos\theta}{2}$	8
1	$T = \dfrac{T_v}{2\cos\theta} = \dfrac{196}{2\cos 22\ 89°} = 106\ \mathrm{N}$	7
2		7

Question D6a(i)
AC frequency
(Outcome 3)

Mark	Solution	Notional level
2	One complete AC cycle happens every complete rotation of the coil Frequency is thus 83 3 Hz	5

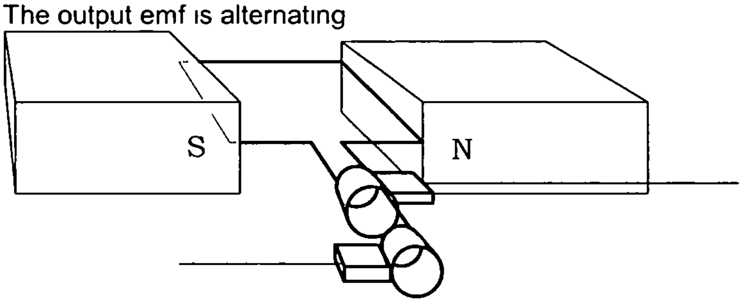
Question D6a(ii)
Power
(Outcome 2)

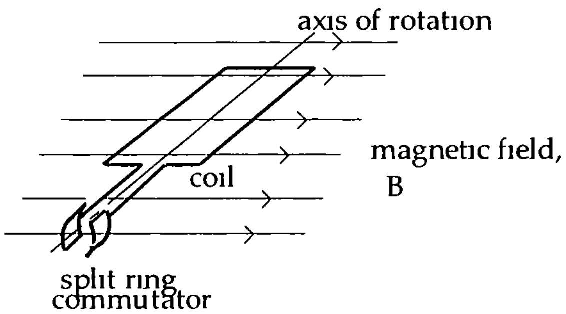
Mark	Solution	Notional level
1	$P = \dfrac{4\ 4^2}{1\ 1}\ \mathrm{W}$	5
1	$P = \dfrac{V^2}{R}$	5
1	$P = 17\ 6\ \mathrm{W}$	5

Question D6b
Magnetic field strength
(Outcome 3)

Mark	Solution	Notional level
1	$\text{emf} = -N\dfrac{B\,\Delta A}{\Delta t}$	5
1	$\Delta A = 140\ \text{mm}^2 = 140 \times 10^{-6}\ \text{m}^2$	6
1	Time for ¼ turn $\Delta t = \dfrac{1}{4} \times \dfrac{1}{83\ 3}\ \text{s} = 0\ 00300\ \text{s}$	7
1	$B = -\dfrac{\text{emf} \times \Delta t}{N \times \Delta A}$ $B = \dfrac{4\ 4 \times 0\ 00300}{400 \times 140 \times 10^{\ 6}}\ \text{T}$ $B = 0\ 236\ \text{T}$	6

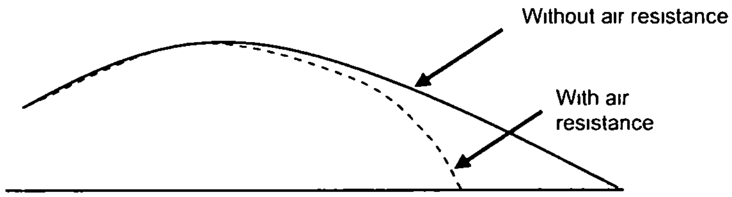
Question D6c
Action of a commutator
(Outcome 3)

Mark	Solution	Notional level
1	Slip-rings allow each brush to be in contact with one end of the coil at all times The output emf is alternating 	5
2	A split-ring commutator alternates the contact between the coil and the brushes This reverse the emf every half rotation, making each brush into a positive or a negative terminal The output emf is direct although it varies from zero to a maximum every half rotation of the coil	7



1	Diagram (above)	6

Question D7a (i), (ii), (iii)
Trajectory and air resistance
(Outcome 3)

Mark	Solution	Notional level
2	Parabolic path (i) 	5
1	As shown above - ball hits the ground earlier (ii)	5
2	Air resistance reduces the ball's velocity (iii)	6

Question D7a (iv)
Acceleration
(Outcome 3)

Mark	Solution	Notional level
1	There is no time at which the ball will have a zero acceleration between the time it is hit and the time it reaches the ground	6
2	The gravitational force provides a constant vertical acceleration	6

Question D7b (i)
Flight time
(Outcome 3)

Mark	Solution	Notional level
1	Ignoring air resistance, consider the vertical direction $v^2 = u^2 + 2gh$	5
1	$v^2 = (55 \text{ x } \sin 1\ 5°)^2 + 2(-9\ 8)(-0\ 35)$ $v = -2\ 99 \text{ m s}^{1}$ (-ve, because downwards)	6
1	$t = \dfrac{v-u}{g}$	7
1	$t = \dfrac{-2\ 99 - (55 \text{ x } \sin 1\ 5°)}{-9\ 8} \text{ s}$ $t = 0\ 452 \text{ s}$	7

Question D7b (ii)
Horizontal range
(Outcome 3)

Mark	Solution	Notional level
1	Ignoring air resistance, consider the horizontal direction $s = v\,t$	7
1	$s = (55 \text{ x } \sin 1\ 5°) \text{ x } 0\ 452$	8
1	$s = 24\ 8 \text{ m}$	8

Question D8a
Distance to galactic centre
(Outcome 3)

Mark	Solution	Notional level
1	one light year $= (3 \times 10^{8}) \times (3600) \times (24) \times (365) = 9\ 46 \times 10^{15}$ m	5
1	distance to centre $= (9\ 46 \times 10^{15}\ \text{m}) \times 30{,}000 = 2\ 84 \times 10^{20}$ m	6

Question D8b
Centripetal acceleration
(Outcome 3)

Mark	Solution	Notional level
1	$a_c = \dfrac{v^2}{r}$	5
1	$v = 250\ \text{km s}^{1} = 250{,}000\ \text{m s}^{1}$ $a_c = \dfrac{(250{,}000)^2}{2\ 84 \times 10^{20}}\ \text{m s}^{2}$	6
1	$a_c = 2\ 20 \times 10^{10}\ \text{m s}^{2}$	6

Question D8c
Orbital period
(Outcome 3)

Mark	Solution	Notional level
1	$v = \dfrac{2\pi r}{T}$	5
1	$T = \dfrac{2\pi r}{v}$	6
1	$T = \dfrac{2 \times \pi \times 2\ 84 \times 10^{20}}{250{,}000}\ \text{s}$ $T = 7\ 13 \times 10^{15}\ \text{s} (= 2\ 3 \times 10^{8}\ \text{years})$	6

Question D8d
Mass of stars
(Outcome 3)

Mark	Solution	Notional level
1	$F_c = F_g$	6
1	$\dfrac{m_{sun} v^2}{r} = G \dfrac{m_{sun} m_{stars}}{r^2}$	7
1	$m_{stars} = \dfrac{v^2 r}{G}$	7
1	$m_{stars} = \dfrac{(250{,}000)^2 \times 2\ 84 \times 10^{20}}{6\ 67 \times 10^{11}}\ \text{kg}$	7
1	$m_{stars} = 2\ 66 \times 10^{41}$ kg	7

Question D8e
Estimate number of stars
(Outcome 3)

Mark	Solution	Notional level
2	assumptions * approximate mass of an average star = 2×10^{30} kg * the mass of dust, gas etc is negligible and there are no other major masses to consider	6
1	Number of Sun-like stars in the galactic centre $\text{number} = \dfrac{\text{total star mass}}{\text{mass Sun}}$ $\text{number} = \dfrac{2.66 \times 10^{41}}{2 \times 10^{30}}\ \text{stars}$ $\text{number} = 1.33 \times 10^{11}\ \text{Sun-like stars}$	7
2	But this is only 90% of stars in the galaxy Thus, $\text{total number} = 1.33 \times 10^{11}\ \text{stars} \times \dfrac{100}{90}$ $\text{total number} = 1.5 \times 10^{11}\ \text{stars}$ OR a comment that 10% extra makes no real difference = 2 marks	8

SECTION E–Optional Section

Question E1
Dual properties of light
(Outcome 2)

Mark	Solution	Notional level
2	Light behaves like a wave, for example when it diffracts	6
2	Light behaves like a stream of particles, for example when some photons excite an atom but others of slightly different energy cannot	6

Question E2
Evidence for the Big Bang
(Outcomes 1, 2 & 3)

Mark	Solution	Notional level
2	Brief description of any one of • cosmic background radiation • predicted abundances of hydrogen and helium match observations • expansion of the Universe • good agreement between independent estimates of the age of the Universe	6
2	Explanation of why this is evidence to support the theory	7

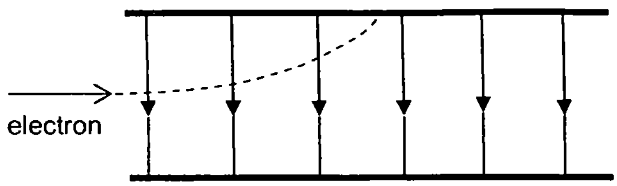
Question E3
Quasar red shift
(Outcome 2)

Mark	Solution	Notional level
2	Red shift explanation	6
2	Link to distance	7

Question E4
de Broglie wavelength
(Outcome 2)

Mark	Solution	Notional level
1	$3\;5\ \text{keV} = 3\;5 \times 10^{3} \times 1\;6 \times 10^{19}\ \text{J}$ $\text{kinetic energy} = 5\;6 \times 10^{16}\ \text{J}$	7
1	$E_k = \frac{1}{2}mv^2$	5
1	$v = \sqrt{\dfrac{2E_k}{m}}$	6
1	$v = \sqrt{\dfrac{2 \times 5\;6 \times 10^{16}}{9\;11 \times 10^{31}}} = 3\;51 \times 10^{7}\ \text{m s}^{1}$	6
1	$\lambda = \dfrac{h}{mv}$	8
1	$\lambda = \dfrac{6\;63 \times 10^{34}}{9\;11 \times 10^{31} \times 3\;51 \times 10^{7}}\ \text{m}$ $\lambda = 2\;08 \times 10^{11}\ \text{m}$	8

Question E5



Electron path
(Outcome 3)

Mark	Solution	Notional level
1	Parabolic path	5
1	Curves upwards	6

Question E6a (i)
Linearising graph
(Outcome 1)

Mark	Solution	Notional level
2	This makes the graph a straight line	7

Question E6a (ii)
Unit of μ
(Outcomes 1 & 3)

Mark	Solution	Notional level
1	$\mu = \frac{T}{v^2} = \frac{\text{force}}{\text{velocity}^2}$	7
1	units of $\mu = \frac{\text{kg m s}^{-2}}{\text{m}^2\ \text{s}^{-2}}$ So the units of μ are kg m^{-1}	7

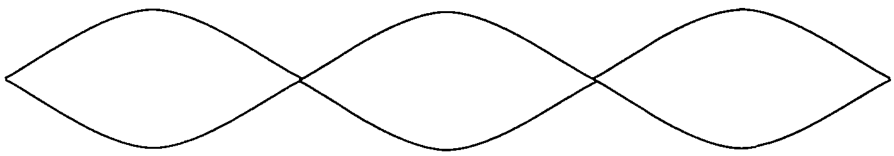
Question E6b
Value of μ
(Outcome 1)

Mark	Solution	Notional level
1	$\text{gradient} = \frac{\text{rise}}{\text{run}}$	5
1	$\text{gradient} = \frac{(45000 - 15000)\,\text{m}^2\ \text{s}^{-2}}{(210 - 75)\,\text{N}}$ $\text{gradient} = 222\ \text{m kg}^{-1}$	6
1	$\text{since } v^2 = \frac{1}{\mu} T$	7
1	$\text{gradient} = \frac{1}{\mu}$	8
1	$\mu = \frac{1}{\text{gradient}} = \frac{1}{222\ 222}\,\text{kg m}^{-1}$ $\mu = 0.00450\ \text{kg m}^{-1}$ (or $4.50\ \text{g m}^{-1}$)	8

Question E6c
Fundamental frequency
(Outcome 3)

Mark	Solution	Notional level
1	The wave velocity is $v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{125}{4\ 5 \times 10^{-3}}}$ $= 166\ 7\ m\ s^{-1}$	6
1	The wavelength is $(2 \times 0\ 76)$ m	7
2	so we can find the frequency $f = \frac{v}{\lambda}$ = 110 Hz	8

Question E6d (i)
Wave envelope
(Outcome 3)

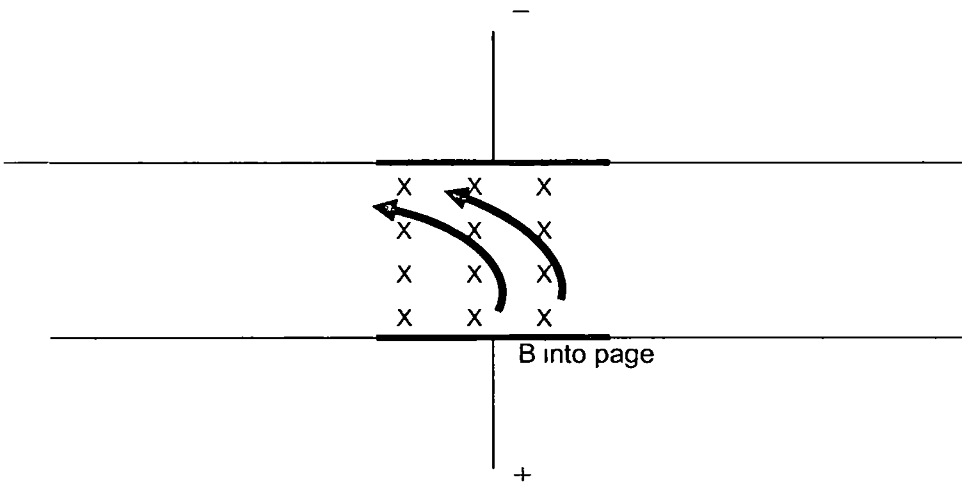
Mark	Solution	Notional level
2	Diagram should show 3 loops as shown in the diagram below 	6

Question E6d (ii)
Transverse-parallel wave coupling
(Outcome 3)

Mark	Solution	Notional level
1	String vibrates transversely to its length	5
1	Sound waves travel transversely to the string	6
1	This is the same as the direction of the vibrations (in air)	7

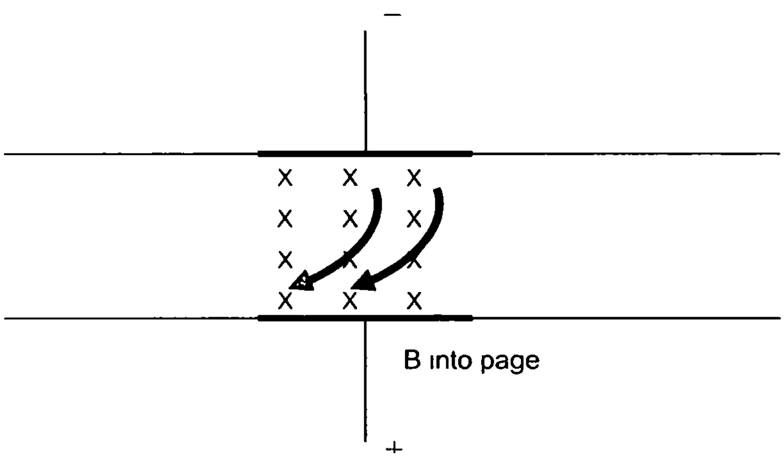
Question E7a
Force on positive charges
(Outcome 3)

Mark	Solution	Notional level
1	path is curved	6
1	to the left	7



Question E7b
Force on negative charges
(Outcome 3)

Mark	Solution	Notional level
1	path is curved	6
1	to the left	7



Question E7c
How the pump works
(Outcome 2)

Mark	Solution	Notional level
2	The electric field accelerates both positively and negatively charged particles so they move across the tube	6
1	Charged particles moving across magnetic field lines experience a magnetic force at right angles to both the movement and the magnetic field	7
1	This pushes the charged particles to the left whether their charge is positive or negative	7
2	The charged particles drag the Solution with them as they move, so the pump moves the entire Solution	8
1	As particles leave the pump to the left, more arrive from the right and the process repeats	8

Question E7d
Energy transfer
(Outcome 2)

Mark	Solution	Notional level
2	The electric field transfers energy to the charged particles	6
2	The charged particles transfer energy to the liquid NOTE The magnetic field does not transfer energy to the charges Students stating that it does incur a penalty of 1 mark	7

Question E8a (i)
Ionisation energy
(Outcome 2)

Mark	Solution	Notional level
1	Minimum energy = 5 3 eV	7

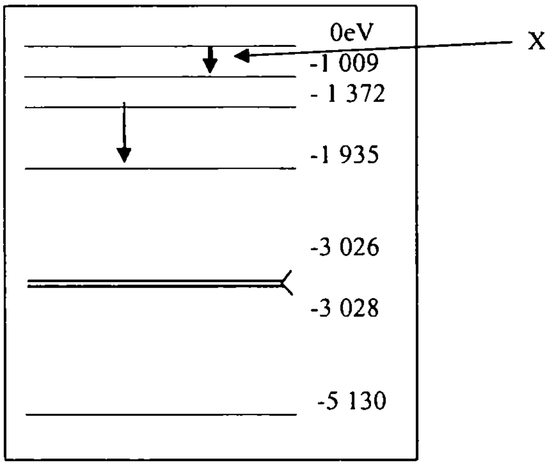
Question E8a (ii)
Decay to lower energy state
(Outcome 2)

Mark	Solution	Notional level
1	The arrow represents an electron falling to a lower energy level	6
1	The result is the emission of a photon	7
1	Whose energy is equal to the energy difference between the levels	8

Question E8b (i)
Sodium-α emission
(Outcome 2)

Mark	Solution	Notional level
1	Two energy levels are very close together Electron transitions from these energy levels to the ground state produce almost equal wavelengths	7
1	$\lambda = \frac{hc}{E}$	7
1	$\lambda = \frac{6\ 626 \times 10^{34} \times 3 \times 10^{8}}{2\ 103 \times 1\ 6 \times 10^{19}} m$ $\lambda = 5\ 91 \times 10^{7} m$ (592 nm)	7

Question E8b (ii)
Other transitions
(Outcome 2)

Mark	Solution	Notional level
1	 On diagram Any transition with a lower energy level difference, eg the transition labelled X above	6
1	Explanation Lower energies correspond to longer wavelengths	7

Question E8c
Spectral fingerprints
(Outcome 2)

Mark	Solution	Notional level
1	There are lines in the spectrum	5
1	Each line represents a transition between energy levels	6
2	These transitions are unique to each element and so can be used to identify specific elements	7

PHYSICS

Formulae and Constants Sheet

151617_4 DOC

Physics Formulae and Constants Sheet

Curriculum Council

Forces and Motion

Mean velocity	$v_{av} = \frac{s}{t} = \frac{v+u}{2}$
Equations of motion	$a = \frac{\Delta v}{\Delta t}$, $s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$, $v = u + at$
Force	resultant $F = ma$
Weight force	$F_{weight} = mg$
Momentum	$p = mv$
Conservation of momentum	$\Sigma p_{before} = \Sigma p_{after}$
Change in momentum	$F\Delta t = mv - mu$
Kinetic energy	$E_k = \frac{1}{2}mv^2$
Gravitational potential energy	$E_p = mg\Delta h$
Work done	$W = Fs = \Delta E$
Power	$P = \frac{W}{t} = \frac{\Delta E}{t} = Fv_{av}$
Centripetal acceleration	$a_c = \frac{v^2}{r}$
Centripetal force	resultant $F = ma = \frac{mv^2}{r}$
Newton's Law of Universal Gravitation	$F = G\frac{m_1 m_2}{r^2}$
Gravitational field strength	$g = G\frac{M}{r^2}$
Moment of a force	$\tau = rF$
Principle of moments	$\Sigma\tau = 0$
Equilibrium of a rigid body	$\Sigma F = 0$ and $\Sigma\tau = 0$

Electricity and Magnetism

Electric current	$I = \frac{q}{t}$
Electric field	$E = \frac{F}{q} = \frac{V}{d}$
Work and energy	$\text{Work} = qV = VIt$
Ohm's Law	$V = IR$
Resistances in series	$R_T = R_1 + R_2 +$
Resistances in parallel	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} +$
Power	$P = VI = I^2R = \frac{V^2}{R}$
Magnetic flux	$\Phi = BA$
Electromagnetic induction	$\text{induced emf} = -N\frac{\Delta\Phi}{\Delta t}$ $\quad$ $\text{induced emf} = \ell v B$
Magnetic force	$F = I\ell B$, $F = qvB$
Transformer turns ratio	$\frac{V_s}{V_p} = \frac{N_s}{N_p}$

Particles and waves

Energy of photon	$E = hf$
Energy transitions	$E_2 - E_1 = hf$
Activity	$A = \frac{\Delta N}{\Delta t}$
Half life	$\frac{1}{2^n} = \frac{A}{A_0}$
Absorbed radiation dose	$\text{absorbed dose} = \frac{E}{m}$
Dose equivalent	dose equivalent = absorbed dose x quality factor
Mass-energy relationship	$\Delta E = (\Delta m)c^2$
Wave period	$T = \frac{1}{f}$
Wave equation	$v_{wave} = f\lambda$
Standing waves	$\text{internodal distance} = \frac{1}{2}\lambda$
Absolute refractive index	$n_x = \frac{c_0}{c_x}$
Snell's Law	$n_1 \sin\theta_1 = n_2 \sin\theta_2$
de Broglie wavelength	$\lambda = \frac{h}{mv}$

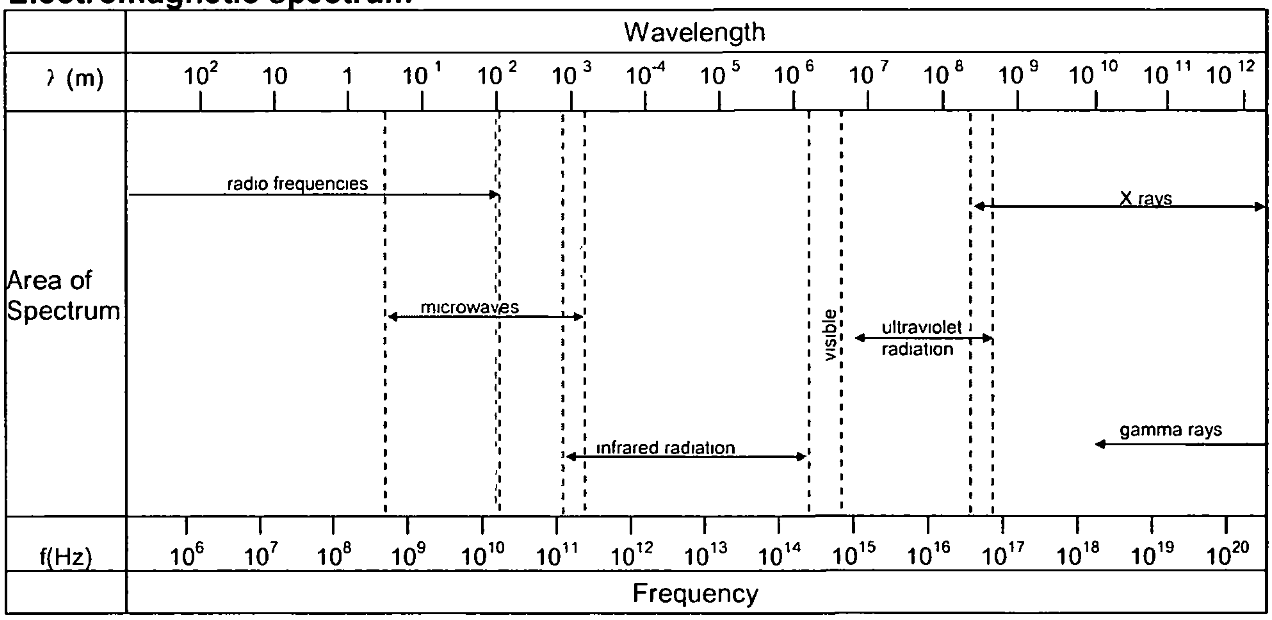
Physical Constants

Speed of light in vacuum or air	c	= 3 00 x 10^{8} m s^{1}
Electron charge	e	= -1 60 x 10^{19} C
Mass of electron	m_e	= 9 11 x 10^{31} kg
Planck's constant	h	= 6 626 x 10^{34} J s
Universal gravitational constant	G	= 6 672 x 10^{11} N m^2 kg^{2}
Electron volt	1 eV	= 1 60 x 10^{19} J
Mass of proton	m_p	= 1 673 x 10^{27} kg
Mass of neutron	m_n	= 1 675 x 10^{27} kg
Mass of alpha	m_α	= 1 675 x 10^{27} kg
Mass – energy equivalent	1 u	=931 5 MeV

Physical Data

Mean acceleration due to gravity on Earth	g	= 9 80 m s^{2}
Mean acceleration due to gravity on the Moon	g_M	= 1 62 m s^{2}
Mean radius of the Earth	R_E	= 6 37 x 10^{6} m
Mass of the Earth	M_E	= 5 98 x 10^{24} kg
Mean radius of the Sun	R_S	= 6 96 x 10^{8} m
Mass of the Sun	M_S	= 1 99 x 10^{30} kg
Mean radius of the Moon	R_M	= 1 74 x 10^{6} m
Mass of the Moon	M_M	= 7 35 x 10^{22} kg
Mean Earth-Moon distance		3 84 x 10^{8} m
Mean Earth-Sun distance		1 50 x 10^{11} m
Power output of the Sun	P_S	= 3 9 x 10^{26} W
Approximate quality factor for alpha radiation	QF_α	= 20
Approximate quality factor for beta radiation	QF_β	= 1
Approximate quality factor for gamma radiation	QF_γ	= 1
Approximate quality factor for slow neutrons	QF_{sn}	= 3
Approximate quality factor for fast neutrons	QF_{fn}	= 10
Tonne		1 tonne = 10^3 kg = 10^6 g

Electromagnetic spectrum



Note 1 Shaded areas represent regions of overlap
2 Gamma rays and X-rays occupy a common region

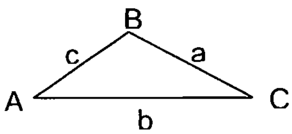
Prefixes of the Metric System

Factor	Prefix	Symbol	Factor	Prefix	Symbol
10^{12}	tera	T	10^{3}	milli	m
10^{9}	giga	G	10^{-6}	micro	μ
10^{6}	mega	M	10^{9}	nano	n
10^{3}	kilo	k	10^{12}	pico	p

Mathematical expressions

Given $ax^2 + bx + c = 0$, $x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

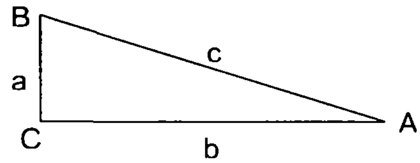
The following expressions apply to the triangle ABC as shown



$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

$$b = \sqrt{a^2 + c^2 - 2ac\cos B}$$

The following expressions apply to the right-angled triangle ABC as shown



$$\text{sine } A = \frac{a}{c}$$

$$\text{cosine } A = \frac{b}{c}$$

$$\text{tangent } A = \frac{a}{b}$$