

A Level Physics

Handbook

Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Tutor: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Target Grade: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Aspirational Grade: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

|  |  |  |  |
| --- | --- | --- | --- |
| Date | Assessment Title /Topic | Grade/ Mark | Area for development (max 2) |
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**Congratulations!**

You have done well at GCSE and now you are moving onto the next stage – A Levels. Physics A Level is both challenging and very rewarding, so it is important you maintain momentum from GCSE and have a plan in place for the next 2 years to achieve the best possible grade.

**This booklet should remain at the front of your day-to-day folder and be brought to every single lesson as it contains useful information throughout.**

On the table below, indicate when your physics lessons are and which of your study periods you will dedicate to completing physics study at school. Add this to your timetable too. Remember you will also need to supplement this with completing homework at home and any extra futures work after the school day.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Monday | Tuesday | Wednesday | Thursday | Friday |
| TW1 |  |  |  |  |  |
| P1 |  |  |  |  |  |
| P2 |  |  |  |  |  |
| P3 |  |  |  |  |  |
| P4 |  |  |  |  |  |
| P5 |  |  |  |  |  |
| P6 |  |  |  |  |  |
| TW2 |  |  |  |  |  |

**Expectations**

**Folder**

You should have two folders: 1 ring binder (day-to-day folder) and 1 lever arch file (long-term folder). Your day-to-day folder will need to be brought to every single physics lesson. Your long-term folder may remain at home unless requested by your teacher.

In your day-to-day folder (ring binder), you will need dividers labelled with each of the following:

1. Teacher 1 notes and definitions
2. Teacher 1 classwork and homework (label each page with c/w or h/w)
3. Teacher 1 independent study
4. Teacher 2 notes and definitions
5. Teacher 2 classwork and homework
6. Teacher 2 independent study (label each page with c/w or h/w)
7. Assessments
8. Futures Work

In your long-term folder (lever-arch), you will need a divider labelled with each of the topics:

1. Measurements and Errors
2. Particles and Radiation
3. Waves
4. Mechanics and Materials
5. Electricity
6. Further Mechanics and Thermal
7. Fields and their consequences
8. Nuclear physics
9. Turning Points in Physics
10. Assessments

**Before your lessons (Preparatory Work)**

You must complete the preparatory work before each of your physics lesson. This will be knowledge you will be asked to recall at the start of the lesson and therefore you will not be able to make the most out of the lesson unless this has been done. Your teacher wants you to make the most amount of progress so will focus on challenging questions and exam techniques in class.

You will be set upLearn as part of your preparatory work. Below indicates which upLearn module you will be set by each teacher as your progress through the course. You should also make sure you are confident on GCSE content that will be relevant to the topic you are learning.

|  |  |  |  |
| --- | --- | --- | --- |
| **Y12 Teacher A** | **Y12 Teacher B** | **Y13 Teacher A** | **Y13 Teacher B** |
| Fundamentals of Successful Learning | Introduction to Motion | Introduction to Fields | Thermal Physics |
| Foundation Maths | Introduction to Forces & Linear Dynamics | Gravitational Force and Field | Ideal Gases & Kinetic Theory of Gases |
| Numbers and Units | Applied Linear Dynamics | Electric Fields | Radioactivity |
| Measurements and Errors | Static and Dynamic Equilibrium | Capacitors | Radioactive Decay |
| Introduction to Waves | Rotational Dynamics & Equilibrium | Magnetic Fields | Nuclear Instability |
| Wave Interactions | Linear Motion | Electromagnetic Induction | Nuclear Energy |
| The Atom and Beyond | Projectile Motion | Exam Questions | Practicals (Paper 3) |
| Particles and Interactions | Momentum |  |  |
| Quantum | Energy, Work and Power |  |  |
| Circuits | Materials |  |  |
| Simple Harmonic Motion | Electricity Introduction |  |  |
|  | Circular Motion |  |  |

If you know in advance that you will not be in the lesson, make sure you have spoken to your teacher about what the class will be covering and ensure this is caught up before the next lesson.

**During your lessons**

Every lesson you should have the following:

* Day-to-day folder
* Calculator
* Black pen, green pen and pencil
* Ruler, protractor and set square
* Lined paper that has been pre-hole-punched and is easily removable from a notebook.
* Preparatory work notes

If you have an unplanned absence in the lesson, it is your responsibility to catch up on the missed learning. The curriculum map shows the topic the class are doing but you should also email your teacher asking for any additional worksheets used.

**After your lessons**

You should make sure you have put all worksheets and your notes into the relevant section of your day-to-day folder.

Make sure you consolidate your learning from lesson time by reviewing your notes and exam questions completed in lesson time. If you did not manage to complete all the questions, you should use some time to do this. If you have not fully understood the concept, revisit the upLearn for the topic or review the notes made in class.

Complete all homework to a high standard. You will always be given at least a week to complete the homework so if you have not understood questions, it is your responsibility to seek out your teacher for help before the due date. No or Incomplete homework will be sanctioned.

**Independent study time**

You should be completing at least 5 hours of work each week on Physics. 2 hours of this will be homework with the remainder being independent work you should complete to support your studies. The table on the next page gives you a breakdown of what you should complete as part of your study. The below links will be helpful to you:

* BBC Bitesize (GCSE): <https://www.bbc.co.uk/bitesize/subjects/zpm6fg8>
* Physics and Maths Tutor (PMT): <https://www.physicsandmathstutor.com/>
* UpLearn: <https://uplearn.co.uk/>
* Kerboodle Textbook: <https://www.kerboodle.com/app> (You can sign in using Microsoft and your school login)
* Isaac Physics: <https://isaacphysics.org/>
* Practice Book for Conceptual Physics – Paul Hewitt
* Maths for A Level Physics – Gareth Kelly and Nigel Wood

The table below shows the range of activities you must complete for each topic. Tick these as you complete them so that it is clear what you still need to complete to achieve the best possible grade.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| For each topic… | GCSE BBC Bitesize | PMT GCSE notes printed and annotated | PMT A Level Definitions made into flashcards | PMT A Level notes printed and annotated | UpLearn | Textbook Summary Questions | PMT Exam LA questions completed and marked | PMT Exam MCQs questions completed and marked | Isaac Physics |
| Measurements and Errors |  |  |  |  |  |  |  |  |  |
| Particle Physics |  |  |  |  |  |  |  |  |  |
| Quantum |  |  |  |  |  |  |  |  |  |
| Waves |  |  |  |  |  |  |  |  |  |
| Mechanics |  |  |  |  |  |  |  |  |  |
| Materials |  |  |  |  |  |  |  |  |  |
| Electricity |  |  |  |  |  |  |  |  |  |
| Periodic Motion |  |  |  |  |  |  |  |  |  |
| Thermal Physics |  |  |  |  |  |  |  |  |  |
| Gravitational fields |  |  |  |  |  |  |  |  |  |
| Electric fields |  |  |  |  |  |  |  |  |  |
| Capacitance |  |  |  |  |  |  |  |  |  |
| Magnetic fields |  |  |  |  |  |  |  |  |  |
| Electromagnetism |  |  |  |  |  |  |  |  |  |
| Nuclear |  |  |  |  |  |  |  |  |  |
| Discovery of the electron |  |  |  |  |  |  |  |  |  |
| Wave-particle duality |  |  |  |  |  |  |  |  |  |
| Special Relativity |  |  |  |  |  |  |  |  |  |
| Required Practicals |  |  |  |  |  |  |  |  |  |

**Curriculum Map**

The below shows the topics that you will be covering throughout the next two years. You should use the curriculum map to help you review previous learning and plan for the topics that are yet to come. If you miss a lesson, the curriculum map will give you an indication of what you need to catch up on. The curriculum map also indicates assessments that are coming up in the year so that you are prepared for these.

Year 12:

|  |  |  |  |
| --- | --- | --- | --- |
| **Date** | **Week** | **Teacher A (3 lessons/week)** | **Teacher B (2 lessons/week)** |
| 2-Sep | 1 | **Topic 1 Measurements and Errors** Units and Prefixes | **Topic 4 Mechanics** Vectors and Scalars |
| 9-Sep | 2 | Micrometers, Vernier Calipers and Transition Assessment | Resolving Forces |
| 16-Sep | 3 | Uncertainties, Graph drawing and uncertainty in graphs | Equilibrium conditions |
| 23-Sep | 4 | Core Practical admin, planning and measuring g core practical | Moments |
| 30-Sep | 5 | **Topic 3 Waves Waves Key Definitions and Phase** | Centre of Mass and Equilibrium |
| 7-Oct | 6 | Superposition and Stationary Waves | Assessment and Motion Graphs |
| 14-Oct | 7 | Stationary waves | SUVAT (1D) |
| 21-Oct | 8 | Stationary Waves Core Practical | SUVAT (2D) |
| 28-Oct | HALF TERM | | |
| 4-Nov | 9 | Refraction and TIR | Projectiles |
| 11-Nov | 10 | Optical Fibres and Diffraction | Newton's laws and Terminal Velocity |
| 18-Nov | 11 | Young's slit | Momentum + Impulse |
| 25-Nov | 12 | Diffraction Grating and Single Slit | Elastic and Inelastic collisions |
| 2-Dec | 13 | Diffraction core practical | Work done, Power and F-x graphs |
| 9-Dec | 14 | Waves Assessment and Revision | Conservation of energy |
| 16-Dec | 15 | Revision | Revision |
| 23-Dec | CHRISTMAS BREAK | | |
| 30-Dec |
| 6-Jan | 16 | January Assessment | January Assessment |
| 13-Jan | 17 | Photons and particle interactions | Density |
| 20-Jan | 18 | Particle zoo and quarks | Springs |
| 27-Jan | 19 | Feedback and Improvement from mock exams | Tensile Stress and strain |
| 3-Feb | 20 | Conservation rules in particles | Young's Modulus |
| 10-Feb | 21 | Photoelectric effect | Feedback and Improvement from mock exams |
| 17-Feb | HALF TERM | | |
| 24-Feb | 22 | Energy levels and excitation | Young's Modulus |
| 3-Mar | 23 | Fluorescence and Quantum feedback task | Materials Required Practical |
| 10-Mar | 24 | Wave-particle duality | Revision and Assessment |
| 17-Mar | 25 | Assessment | **Topic 5 Electricity** Recap GCSE Basics and Resistivity |
| 24-Mar | 26 | Resistors in series and parallel + Kirchhoff's first law | Superconductivity and feedback task |
| 31-Mar | 27 | Kirchhoff's laws | Resistivity Core Practical |
| 7-Apr | EASTER BREAK | | |
| 14-Apr |
| **21-Apr** | 28 | Potential divider and Sensor Circuits | Exam Practice (Practical Skills) |
| **28-Apr** | 29 | Internal Resistance | Internal Resistance core practical |
| **5-May** | 30 | Revision | Exam Practice (Practical Skills) |
| **12-May** | 31 | Assessment | Revision |
| **19-May** | 32 | Revision | Revision |
| **26-May** | HALF TERM | | |
| **2-Jun** | 33 | Revision | Revision |
| **9-Jun** | 34 | Revision | Revision |
| **16-Jun** | 35 | UCAS Exams | UCAS Exams |
| **23-Jun** | 36 | **Topic 6 Periodic Motion Simple Harmonic Motion** | **Topic 6 Periodic Motion** Circular motion |
| **30-Jun** | 37 | Simple Harmonic Motion | Circular motion |
| **7-Jul** | 38 | Feedback and Improvement from UCAS exams | Feedback and Improvement from UCAS exams |
| **14-Jul** | 39 | Simple Harmonic Motion Practical | Circular motion |
| **21-Jul** | 40 | Resonance and Damping | Circular motion |

Y13:

|  |  |  |  |
| --- | --- | --- | --- |
| **Date** | **Week** | **Teacher A (3 lessons/week)** | **Teacher B (2 lessons/week)** |
| 2-Sep | 1 | **Topic 7 Fields** Fields and Newton's law of Gravitation | **Topic 6.1 Periodic Motion** Periodic Motion Recap |
| 9-Sep | 2 | Gravitational field strength | Periodic motion recap and core practical |
| 16-Sep | 3 | Gravitational potential | Periodic motion recap and core practical |
| 23-Sep | 4 | Planetary fields and Satellite Motion | Paper 1 Assessment including periodic motion |
| 30-Sep | 5 | Revision and Gravitational Fields Assessment | **Topic 8 Radioactivity** Changes in the nucleus |
| 7-Oct | 6 | Electric fields and Coulomb's law | Gamma Intensity Core Practical |
| 14-Oct | 7 | Electric potential | Half life |
| 21-Oct | 8 | Gravitational fields vs Electric fields | Instability and decay modes |
| 28-Oct | HALF TERM | | |
| 4-Nov | 9 | Fields Assessment and Capacitance | Uses of radioactive isotopes and nuclear radius |
| 11-Nov | 10 | Dielectric and Capacitor graphs | Binding energy |
| 18-Nov | 11 | Capacitor equations and time constant | Fission and Fusion |
| 25-Nov | 12 | Capacitance Core Practical | The Nuclear Reactor and Revision |
| 2-Dec | 13 | Magnetic Fields and Motor Effect | Revision and Radioactivity Assessment |
| 9-Dec | 14 | Motion of charged particles in B field | **Topic 6.3-4 Thermal Physics** Internal energy and SHC |
| 16-Dec | 15 | Cyclotrons and Hall Effect | SHC and Latent heat |
| 23-Dec | CHRISTMAS BREAK | | |
| 30-Dec |
| 6-Jan | 16 | Mock Exams | Mock Exams |
| 13-Jan | 17 | Magnetic fields Core Practical | Experimental gas laws |
| 20-Jan | 18 | Definitions of EM induction | Ideal gas and Kinetic energy |
| 27-Jan | 19 | Lenz's and Faraday's law | Thermal Core Practical |
| 3-Feb | 20 | AC Generator | Review of Jan exam and knowledge/skill gaps topics |
| 10-Feb | 21 | Review of Jan exam and knowledge/skill gaps topics | Review of Jan exam and knowledge/skill gaps topics |
| 17-Feb | HALF TERM | | |
| 24-Feb | 22 | Alternating current and power | Revision and Thermal Physics Assessment |
| 3-Mar | 23 | EM Core Practical | **Topic 9 Turning Points** Discovery of the Electron |
| 10-Mar | 24 | Transformers and Assessment | Crossed beams and Fine beam method |
| 17-Mar | 25 | **Topic 9 Turning Points** Special relativity | Light and Electromagnetic waves |
| 24-Mar | 26 | Special relativity | Wave particle duality and electron microscopes |
| 31-Mar | 27 | Turning Points Revision | Turning Points |
| 7-Apr | EASTER BREAK | | |
| 14-Apr |
| **21-Apr** | 28 | Mock exams | Mock exams |
| **28-Apr** | 29 | Revision | Practical skills revision |
| **5-May** | 30 | Revision | Practical skills revision |
| **12-May** | 31 | Revision | Revision |
| **19-May** | 32 | Revision | Revision |
| **26-May** | HALF TERM | | |

**Futures Work**

Physics and its related disciplines (engineering, medical physics, astrophysics, etc.) are fantastic courses to do at university. Spend some time throughout Y12 and Y13 understanding the wider aspect of physics and how influential it is in modern times. Below are a list of activities you can undertake to help you:

The following places are constantly holding public lectures for everyone to go and enjoy. Have a browse at their upcoming events, get yourself some tickets and go with your friends or family.

* Royal Institution (RI)
* Royal Society
* Institute of Physics (IOP) – You can also become a student member
* CERN Public Lectures: <https://home.cern/tags/public-lecture>
* Hintze Lectures: <https://www2.physics.ox.ac.uk/about-us/outreach/public/public-lectures/the-hintze-lectures>
* University Public Lectures
  + UCL: <https://www.ucl.ac.uk/physics-astronomy/outreach/science-centre-lectures>
  + King’s Collect London: <https://www.kcl.ac.uk/physics/events>
  + Imperial College London: <https://www.imperial.ac.uk/whats-on/>
  + Oxford University: <https://www2.physics.ox.ac.uk/about-us/outreach/public/public-lectures/physics-school-seminar-series>

The following books are some fantastic reads that not only help you understand physics better but also showcase the vast nature of physics. You should try to read a few of these over the course of the 2 years.

* Quantum – Manjit Kumar
* Universe in a nutshell – Stephen Hawking
* The Elegant Universe – Brian Greene
* E = mc2 and why should we care – Brian Cox and Jeff Forshaw
* Does God play dice? – Ian Stewart
* Six Easy Pieces/Six Not so Easy Pieces – Richard Feynman
* A Short History of Nearly Everything – Brian Bryson
* What If? – Randall Munroe
* Seven Brief Lessons on Physics – Carlo Rovelli

If you are looking for shorter articles about the current advancements in the physics world then have a browse of the following magazines:

* Physics world magazine
* New Scientist magazine
* Science Daily
* Physics Review

The following companies regularly update their websites with summer schools, workshops and competitions. Keep checking if there is something regarding the future university degree or career you want to do.

* Isaac Physics: <https://isaacphysics.org/events?stage=all>
* In 2 Science UK: <https://in2scienceuk.org/students/apply/>
* OxSci (Science writing competition: <https://oxsci.org/schools/>
* Brilliant.org: <https://brilliant.org/>
* Sutton Trust
* Minds Underground
* Study Mind
* Queen Mary (often hold a summer school)
* National Physics Laboratory

**A-Level Paper 1 Personal Learning Checklist**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **1. Measurements and Errors** | | | | |
| **LO** | **Learning Objectives:** | **Confidence** | | |
|  |  |  |
| **1.01** | Recall the fundamental (base) units for: mass, length, time, amount of substance, temperature and electric current. |  |  |  |
| **1.02** | Derive the SI units for other quantities. |  |  |  |
| **1.03** | Recall and use the prefixes: T, G, M, k, c, m, μ, n, p and f. |  |  |  |
| **1.04** | Convert between units of the same quantity for example J, eV and kW h. |  |  |  |
| **1.05** | Identify random and systematic errors in a practical. |  |  |  |
| **1.06** | Suggest ways to reduce random and systematic errors in a practical. |  |  |  |
|  | ***Understand and use the following terms correctly:*** | | | |
| **1.07** |          precision |  |  |  |
| **1.08** |          repeatability |  |  |  |
| **1.09** |          reproducibility |  |  |  |
| **1.10** |          resolution |  |  |  |
| **1.11** |          accuracy |  |  |  |
| **1.12** | State a quantity to the appropriate number of significant figures based on the value and its associated uncertainty. |  |  |  |
|  | ***Calculate the following:*** |  |  |  |
| **1.13** |          absolute uncertainty |  |  |  |
| **1.14** |          fractional uncertainty |  |  |  |
| **1.15** |          percentage uncertainty |  |  |  |
| **1.16** |          combination of absolute and percentage uncertainties |  |  |  |
| **1.17** |          combining uncertainties in cases where the measurements have been added, subtracted, multiplied, divided, or raised to powers. |  |  |  |
| **1.18** | Draw error bars on a graph relating to the uncertainty in a data point. |  |  |  |
| **1.19** | Calculate the uncertainty in the gradient of a straight-line graph. |  |  |  |
| **1.20** | Calculate the uncertainty in the y-intercept of a straight-line graph. |  |  |  |
| **1.21** | Explain why individual points on a graph may or may not have associated error bars. |  |  |  |
| **1.22** | Estimate approximate values of physical quantities to the nearest order of magnitude. |  |  |  |
| **1.23** | Use common estimates and knowledge of physics to produce further derived estimates to the nearest order of magnitude. |  |  |  |
|  |  |  |  |  |
| **2. Particles and Radiation** | | | | |
| **LO** | **Learning Objectives:** | **Confidence** | | |
|  |  |  |
| **2.01** | Recall the model of the atom, including the proton, neutron and electron. |  |  |  |
| **2.02** | Recall the charge and mass of the proton, neutron and electron in SI units and relative units. |  |  |  |
| **2.03** | Understand what is meant by the atomic mass unit (amu). |  |  |  |
| **2.04** | Calculate the specific charge of the proton and the electron, and of nuclei and ions. |  |  |  |
| **2.05** | Use nuclide notation, and understand what Z and A stand for in this notation. |  |  |  |
| **2.06** | Define isotope. |  |  |  |
| **2.07** | Use isotopic data in calculations. |  |  |  |
| **2.08** | Describe the strong nuclear force. |  |  |  |
| **2.09** | Explain the role of the strong nuclear force in keeping the nucleus stable. |  |  |  |
| **2.10** | Describe alpha and beta decay. |  |  |  |
| **2.11** | Write equations for alpha and beta decay. |  |  |  |
| **2.12** | Explain the need for the neutrino in beta decay. |  |  |  |
| **2.13** | Describe what is meant by the term ‘antiparticle’. |  |  |  |
| **2.14** | Compare particles and antiparticles in terms of their mass, charge and rest energy in MeV. |  |  |  |
| **2.15** | State the antiparticles of the electron, proton, neutron and neutrino. |  |  |  |
| **2.16** | State what is meant by a ‘photon’. |  |  |  |
| **2.17** | Understand how energy of a photon is related to the frequency of radiation. |  |  |  |
| **2.18** | Use the following equation: E = hf = hc / λ |  |  |  |
| **2.19** | Describe the process of annihilation. |  |  |  |
| **2.20** | Describe the process of pair production. |  |  |  |
| **2.21** | Describe and calculate the energies involved in annihilation and pair production. |  |  |  |
| **2.22** | State the four fundamental interactions. |  |  |  |
| **2.23** | Describe the four fundamental interactions and their exchange particles. |  |  |  |
| **2.24** | State what is meant by exchange particles. |  |  |  |
|  | ***Draw Feynman diagrams for the following interactions:*** | | | |
| **2.25** |          β− decay. |  |  |  |
| **2.26** |          β+ decay. |  |  |  |
| **2.27** |          electron capture. |  |  |  |
| **2.28** |          electron – proton collision |  |  |  |
| **2.29** |          neutron – neutrino. |  |  |  |
| **2.30** | Describe how we can classify particles into two groups: hadrons and leptons. |  |  |  |
| **2.31** | Describe the two classes of hadrons: baryons and mesons. |  |  |  |
| **2.32** | Conserve baryon number. |  |  |  |
| **2.33** | Describe what kaons are. |  |  |  |
| **2.34** | Describe what kaons can decay into. |  |  |  |
| **2.35** | Conserve lepton number. |  |  |  |
| **2.36** | State when strange particles are produced. |  |  |  |
| **2.37** | State when strangeness is conserved and not conserved. |  |  |  |
| **2.38** | Apply all the conservation rules (charge, baryon number, lepton number and strangeness, if necessary) to be able to predict products of interactions. |  |  |  |
| **2.39** | Appreciate that particle physics relies on the collaborative efforts of large teams of scientists and engineers to validate new knowledge. |  |  |  |
| **2.40** | Understand what quarks are. |  |  |  |
| **2.41** | Describe the properties of quarks and antiquarks. |  |  |  |
| **2.42** | State how many quarks are needed in a baryon and how many needed in a meson. |  |  |  |
| **2.43** | Be able to identify the quark make up of particles in terms of the following quarks: up (u), down (d) and straneg (s). |  |  |  |
| **2.44** | State what a neutron decays into. |  |  |  |
| **2.45** | Describe the change in quark character in in β− and in β+ decay. |  |  |  |
| **2.46** | State that energy and momentum are conserved in all interactions. |  |  |  |
| **2.47** | Describe the photoelectric effect. |  |  |  |
| **2.48** | State what is meant by the threshold frequency. |  |  |  |
| **2.49** | Explain how the presence of a threshold frequency was evidence for photon theory. |  |  |  |
| **2.50** | State what is meant by the work function, φ. |  |  |  |
| **2.51** | Explain what a stopping potential is. |  |  |  |
| **2.52** | Understand and use the photoelectric equation: hf = φ + Ek(max) |  |  |  |
| **2.53** | Explain why the kinetic energy in the photoelectric equation is a maximum. |  |  |  |
|  | ***State what is meant by the following words:*** |  |  |  |
| **2.54** |          ionisation |  |  |  |
| **2.55** |          excitation |  |  |  |
| **2.56** |          ground state |  |  |  |
| **2.57** |          de-excitation |  |  |  |
| **2.58** |          electron volt |  |  |  |
| **2.59** | Describe how electrons can be ionised or excited. |  |  |  |
| **2.60** | Describe what happens when an electron is de-excited. |  |  |  |
| **2.61** | Describe what happens in a fluorescent tube. |  |  |  |
| **2.62** | Convert from eV to joules and vice versa. |  |  |  |
| **2.63** | Describe what a line spectra shows. |  |  |  |
| **2.64** | Explain how a line spectra is evidence for transitions between discrete energy levels. |  |  |  |
| **2.65** | Understand and use the following equation: hf = E1 – E2 |  |  |  |
| **2.66** | Explain what electron diffraction is and how it suggests that particles possess wave properties. |  |  |  |
| **2.67** | Calculate de Broglie wavelength using the equation 𝜆 = h /(𝑚𝑣) |  |  |  |
| **2.68** | Explain how and why the amount of diffraction changes when the momentum of the particle is changed. |  |  |  |
| **2.69** | Appreciate knowledge and understanding of the nature of matter changes over time. |  |  |  |
| **2.70** | Appreciate that such changes need to be evaluated through peer review and validated by the scientific community. |  |  |  |
|  |  |  |  |  |
| **3. Waves** | | | | |
| **LO** | **Learning Objectives:** | **Confidence** | | |
|  |  |  |
| **3.01** | Define what a progressive wave is. |  |  |  |
|  | ***Define the following words and state their units:*** | | | |
| **3.02** |          amplitude |  |  |  |
| **3.03** |          frequency |  |  |  |
| **3.04** |          wavelength |  |  |  |
| **3.05** |          speed |  |  |  |
| **3.06** |          phase |  |  |  |
| **3.07** |          phase difference |  |  |  |
| **3.08** |          time period |  |  |  |
| **3.09** | Carry out calculations using the wave equation, c = fλ. |  |  |  |
| **3.10** | Carry out calculations using the time period equation, T= 1/f. |  |  |  |
| **3.11** | Describe a transverse wave and give examples. |  |  |  |
| **3.12** | Describe a longitudinal wave and give examples. |  |  |  |
| **3.13** | Compare transverse waves and longitudinal waves. |  |  |  |
| **3.14** | State common features of all electromagnetic waves. |  |  |  |
| **3.15** | Define polarisation. |  |  |  |
| **3.16** | Explain why polarisation can only happen for transverse waves. |  |  |  |
| **3.17** | Describe uses of polarisers, including Polaroid material and the alignment of aerials. |  |  |  |
| **3.18** | Define what a stationary wave is. |  |  |  |
| **3.19** | Explain how a stationary wave is formed from two progressive waves travelling in opposite directions towards each other. |  |  |  |
| **3.20** | Draw a stationary wave. |  |  |  |
| **3.21** | Define nodes and antinodes. |  |  |  |
| **3.22** | Label nodes and antinodes onto a graphical depiction of a standing wave. |  |  |  |
| **3.23** | Explain what harmonics are. |  |  |  |
| **3.24** | Calculate the first harmonic using the equation. |  |  |  |
| **3.25** | Calculate further harmonics by understanding what happens to the frequency as the order of the harmonic increases. |  |  |  |
| **3.26** | Describe how standing waves are formed in different scenarios including on a string and in a microwave. |  |  |  |
| **3.27** | ***Core Practical: Investigation into the variation of the frequency of stationary waves on a string with length, tension, and mass per unit length of the string.*** | | | |
| **3.28** | Define the term path difference. |  |  |  |
| **3.29** | Define coherence. |  |  |  |
| **3.30** | State an example of monochromatic light. |  |  |  |
| **3.31** | Explain constructive and destructive interference. |  |  |  |
| **3.32** | Describe diffraction. |  |  |  |
| **3.33** | Describe the pattern produced when coherent light is passed through a double-slit. (Young’s double slit experiment). |  |  |  |
| **3.34** | Explain how the pattern is produced in a double-slit experiment. |  |  |  |
| **3.35** | Describe the safety issues associated with using lasers. |  |  |  |
| **3.36** | Understand and use the following equation w = λD/s. |  |  |  |
| **3.37** | Describe and explain what the pattern would look like if using white light. |  |  |  |
| **3.38** | Describe the interference produced with sound and electromagnetic waves. |  |  |  |
| **3.39** | Appreciate how knowledge and understanding of nature of electromagnetic radiation has changed over time. |  |  |  |
| **3.40** | Describe the pattern produced when monochromatic light is shone through a single slit. |  |  |  |
| **3.41** | Describe the pattern produced when white light is shone through a single slit. |  |  |  |
| **3.42** | State and explain how the variation of the width of the central diffraction maximum is affected by wavelength and slit width. |  |  |  |
| **3.43** | Derive and use dsinθ = nλ |  |  |  |
| **3.44** | Describe the pattern produced by a plane transmission diffraction grating at normal incidence. |  |  |  |
| **3.45** | Describe the uses of application gratings. |  |  |  |
| **3.46** | Understand what refraction is and what causes refraction. |  |  |  |
| **3.47** | Understand and use the equation for the refractive index of a substance: n = c / cs |  |  |  |
| **3.48** | State the refractive index of air. |  |  |  |
| **3.49** | Understand and use Snell’s law of refraction for a boundary: n1sin θ1 = n2sin θ2 |  |  |  |
| **3.50** | Describe what total internal reflection is. |  |  |  |
| **3.51** | Explain when total internal reflection occurs with reference to the critical angle. |  |  |  |
| **3.52** | Be able to calculate the critical angle for a medium: sin θc = n2 / n1 |  |  |  |
| **3.53** | Explain how simple fibre optics work. |  |  |  |
| **3.54** | Explain the function of cladding in optical fibres. |  |  |  |
| **3.55** | Describe what is meant by material dispersion. |  |  |  |
| **3.56** | Describe what is meant by modal dispersion. |  |  |  |
| **3.57** | Describe the principles of pulse broadening and absorption. |  |  |  |
| **3.58** | Describe the consequences of pulse broadening and absorption. |  |  |  |
| **3.59** | ***Core Practical: Investigation of interference effects to include the Young’s slit experiment and interference by a diffraction grating.*** | | | |
|  |  |  |  |  |
| **4. Mechanics and Materials** | | | | |
| **LO** | **Learning Objectives:** | **Confidence** | | |
|  |  |  |
| **4.01** | State what is meant by the term scalar. |  |  |  |
| **4.02** | State what the term vector means. |  |  |  |
| **4.03** | Give examples of vectors and scalars. |  |  |  |
| **4.04** | Calculate the resultant vector numerically or by scale drawing. (Calculations will be limited to two vectors at right angles). |  |  |  |
| **4.05** | Resolve vectors into two components at right angles to each other (vertically and horizontally). |  |  |  |
| **4.06** | Resolve vectors into two components that are along and perpendicular to an inclined plane. |  |  |  |
| **4.07** | State what is meant by the term coplanar. |  |  |  |
| **4.08** | State the conditions for equilibrium for two forces acting at a point. |  |  |  |
| **4.09** | State the conditions for equilibrium for three coplanar forces acting at a point. |  |  |  |
| **4.10** | Describe the motion of an object that is in equilibrium. |  |  |  |
| **4.11** | State what ‘moment’ means. |  |  |  |
| **4.12** | Calculate the moment of a force about a point. |  |  |  |
| **4.13** | State what ‘couple’ means. |  |  |  |
| **4.14** | Calculate the moment of a couple. |  |  |  |
| **4.15** | State the principle of moments. |  |  |  |
| **4.16** | Apply the principle of moments to a given context. |  |  |  |
| **4.17** | State what is meant by centre of mass. |  |  |  |
| **4.18** | Explain why the centre of mass of a uniform regular object is at its centre. |  |  |  |
|  | ***Define the following words:*** | | | |
| **4.19** |          displacement |  |  |  |
| **4.20** |          speed |  |  |  |
| **4.21** |          velocity |  |  |  |
| **4.22** |          acceleration |  |  |  |
| **4.23** | Apply the equations for velocity and acceleration, including average and instantaneous speeds and velocities. |  |  |  |
| **4.24** | Represent uniform and non-uniform acceleration on graphs. |  |  |  |
| **4.25** | Deduce what the area under an acceleration-time graph represents. |  |  |  |
| **4.26** | Draw a velocity-time graph. |  |  |  |
| **4.27** | Deduce what the gradient and area under a velocity-time graph represents. |  |  |  |
| **4.28** | Apply and use the equations for uniform acceleration (SUVAT) for one-dimension one-direction problems. |  |  |  |
| **4.29** | Apply and use the equations for uniform acceleration (SUVAT) for one-dimension problems. |  |  |  |
| **4.30** | Understand the independent effect of motion in the horizontal and vertical directions in a uniform gravitational field. |  |  |  |
| **4.31** | Apply and use the equations for uniform acceleration (SUVAT) for two dimension problems. |  |  |  |
| **4.32** | Describe the effect of friction. |  |  |  |
| **4.33** | Describe the effect of lift and drag forces. |  |  |  |
| **4.34** | Explain what is meant by terminal speed and when it occurs. |  |  |  |
| **4.35** | Describe what happens to air resistance with increased speed. |  |  |  |
| **4.36** | Explain what effect air resistance has on the trajectory of a projectile. |  |  |  |
| **4.37** | State the factors that affect the maximum speed of a vehicle. |  |  |  |
| **4.38** | State the three laws of motion |  |  |  |
| **4.39** | Apply the three laws of motion to appropriate situations. |  |  |  |
| **4.40** | Understand and use F=ma in situations where the mass is constant. |  |  |  |
| **4.41** | Define momentum as mass x velocity. |  |  |  |
| **4.42** | State the conservation of linear momentum. |  |  |  |
| **4.43** | Apply the conservation of linear momentum to problems in one dimension. |  |  |  |
| **4.44** | State force as the rate of change of momentum and apply the equation F = Δmv / Δt. |  |  |  |
| **4.45** | Define impulse. |  |  |  |
| **4.46** | Deduce what the area under a force-time graph represents. |  |  |  |
| **4.47** | Explain how impact forces are related to contact time (eg kicking a football, crumple zones, packaging). |  |  |  |
| **4.48** | State what is meant by an elastic and inelastic collision. |  |  |  |
| **4.49** | Carry out calculations involving elastic and inelastic collisions. |  |  |  |
| **4.50** | Carry out calculations involving explosions. |  |  |  |
| **4.51** | Appreciate the use of momentum conservation issues in the context of ethical transport design. |  |  |  |
| **4.52** | ***Core Practical: Determination of g by a free-fall method.*** | | | |
| **4.53** | Calculate the energy transferred using the equation: W = Fs cosθ |  |  |  |
| **4.54** | State what is meant by the term ‘power’. |  |  |  |
| **4.55** | Calculate the power using P = ΔW / Δt = Fv |  |  |  |
| **4.56** | Explain what would happen to power if the force was not constant. |  |  |  |
| **4.57** | Deduce what the area under a force-displacement graph represents. |  |  |  |
| **4.58** | State what is meant by the term efficiency. |  |  |  |
| **4.59** | Calculate efficiency using efficiency = useful output power / input power. |  |  |  |
| **4.60** | Express efficiency as a percentage. |  |  |  |
| **4.61** | State what the principle of conservation of energy is. |  |  |  |
| **4.62** | Apply the principle of conservation of energy. |  |  |  |
| **4.63** | Calculate change in gravitational potential energy. |  |  |  |
| **4.64** | Calculate kinetic energy. |  |  |  |
| **4.65** | Describe and explain applications of energy conservation to examples involving gravitational potential energy, kinetic energy, and work done against resistive forces. |  |  |  |
| **4.66** | State what is meant by density. |  |  |  |
| **4.67** | Calculate density using ρ = m / V. |  |  |  |
| **4.68** | State Hooke’s law. |  |  |  |
| **4.69** | State what is meant by elastic limit. |  |  |  |
| **4.70** | Understand and apply F = kΔL to an example. |  |  |  |
| **4.71** | Define tensile strain. |  |  |  |
| **4.72** | Define tensile stress. |  |  |  |
| **4.73** | Calculate tensile strain. |  |  |  |
| **4.74** | Calculate tensile stress. |  |  |  |
| **4.75** | Calculate the elastic strain energy using the equation. |  |  |  |
| **4.76** | Deduce the elastic strain energy from a force-extension graph. |  |  |  |
| **4.77** | Calculate breaking stress. |  |  |  |
|  | ***Describe the following words:*** | | | |
| **4.78** |          plastic behaviour |  |  |  |
| **4.79** |          fracture |  |  |  |
| **4.80** |          brittle behaviour |  |  |  |
| **4.81** | Link the above words to force- extension graphs. |  |  |  |
| **4.82** | Quantitative and qualitative application of energy conservation to examples involving elastic strain energy and energy to deform. |  |  |  |
| **4.83** | Convert from elastic potential energy to kinetic and gravitational potential energy. |  |  |  |
| **4.84** | Interpret stress-strain curves. |  |  |  |
| **4.85** | Appreciate use of energy conservation issues in the context of ethical transport design. |  |  |  |
| **4.86** | Define Young’s modulus. |  |  |  |
| **4.87** | Calculate Young’s modulus as stress/strain. |  |  |  |
| **4.88** | Use a stress-strain graph to deduce Young’s modulus. |  |  |  |
| **4.89** | ***Core practical: Determination of the Young modulus by a simple method.*** | | | |
|  |  |  |  |  |
| **5. Electricity** | | | | |
| **LO** | **Learning Objectives:** | **Confidence** | | |
|  |  |  |
|  | ***Define the following terms:*** | | | |
| **5.01** |          Current |  |  |  |
| **5.02** |          Charge |  |  |  |
| **5.03** |          Potential difference |  |  |  |
| **5.04** |          Resistance |  |  |  |
|  | ***Calculate quantities using the following equations:*** | | | |
| **5.05** |          I = ΔQ / Δt |  |  |  |
| **5.06** |          V = W / Q |  |  |  |
| **5.07** |          R = V / I |  |  |  |
| **5.08** | Interpret current – voltage graphs and distinguish between the characteristics for an ohmic conductor, a semiconductor diode and a filament lamp. (I or V can be on the x-axis) |  |  |  |
| **5.09** | State Ohm’s law. |  |  |  |
| **5.10** | Recognise that Ohm’s law is a special case where I is directly proportional to V under constant physical conditions. |  |  |  |
| **5.11** | Describe why ammeters must be connected in series and voltmeters in parallel. (Ammeters and voltmeters should be treated as ideal unless specifically stated) |  |  |  |
| **5.12** | Define resistivity. |  |  |  |
| **5.13** | Suggest reasons why resistivity is a better quantity to state than resistance. |  |  |  |
| **5.14** | Understand and use the resistivity equation: ρ = RA / L |  |  |  |
| **5.15** | Describe and explain the effect of temperature on the resistance of metal conductors. |  |  |  |
| **5.16** | Describe the effect of temperature on the resistance of thermistors. (Only negative temperature coefficient, ntc, thermistors will be considered). |  |  |  |
| **5.17** | Describe application of thermistors, including in temperature sensors. |  |  |  |
| **5.18** | Explain what ‘superconductor’ means. |  |  |  |
| **5.19** | Describe how superconductors can be used to produce strong magnetic fields and to reduce energy losses in the transmission of electric power. |  |  |  |
| **5.20** | ***Core Practical: Determination of resistivity of a wire using a micrometer, ammeter, and voltmeter.*** | | | |
| **5.21** | Calculate the value for total resistance when resistors are connected in series. |  |  |  |
| **5.22** | Calculate the value for total resistance when resistors are connected in parallel. |  |  |  |
| **5.23** | Calculate values for resistance when components are connected in a combination of series and parallel. |  |  |  |
| **5.24** | Calculate electrical energy using the equation, E = IVt. |  |  |  |
| **5.25** | Calculate electrical power using: P = IV = I2R = V2/R. |  |  |  |
| **5.26** | State Kirchhoff’s first law. |  |  |  |
| **5.27** | Explain why current into a junction must equal the current exiting a junction. |  |  |  |
| **5.28** | Calculate current in a series or parallel circuit. |  |  |  |
| **5.29** | State Kirchhoff’s second law. |  |  |  |
| **5.30** | Define potential difference. |  |  |  |
| **5.31** | Define electromotive force. |  |  |  |
| **5.32** | Calculate the potential difference of components in series or parallel circuits. |  |  |  |
| **5.33** | Explain what happens to cells that are combined in series. |  |  |  |
| **5.34** | Explain what happens to cells that are combined in parallel. |  |  |  |
| **5.35** | Describe what a potential divider does. |  |  |  |
| **5.36** | Describe the purpose of a negative temperature coefficient (ntc) thermistor and draw the circuit symbol. |  |  |  |
| **5.37** | Describe the purpose of a light dependent resistor (LDR) and draw the circuit symbol. |  |  |  |
| **5.38** | Derive the equation for a potential divider. |  |  |  |
| **5.39** | Explain what happens to the output voltage of a potential divider when changes are made to the circuit, including circuits with a thermistor and LDR. |  |  |  |
| **5.40** | Understand what internal resistance is. |  |  |  |
| **5.41** | Define terminal potential difference. |  |  |  |
|  | **Apply the following equations to a circuit:** | | | |
| **5.42** |          ε = E/Q |  |  |  |
| **5.43** |          ε = I (R + r) |  |  |  |
| **5.44** | Preform calculations for circuits where the internal resistance is **not** negligible. |  |  |  |
| **5.45** | ***Core Practical: Investigation of the emf and internal resistance of electric cells and batteries by measuring the variation of the terminal pd of the cell with current in it.*** | | | |
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| **6A. Further Mechanics** | | | | |
| **LO** | **Learning Objectives:** | **Confidence** | | |
|  |  |  |
| **6A.01** | Describe the motion in a circular path at constant speed. |  |  |  |
| **6A.02** | Explain why motion in circular path requires a centripetal force. |  |  |  |
| **6A.03** | Estimate the acceleration and centripetal force in situations that involve rotation. |  |  |  |
| **6A.04** | State the centripetal force in a situation. |  |  |  |
| **6A.05** | Calculate the magnitude of angular speed using ω = v / r = 2πf. |  |  |  |
| **6A.06** | Convert between radians and degrees. |  |  |  |
| **6A.07** | Calculate centripetal acceleration using a = v2/r = ω2r. |  |  |  |
| **6A.08** | Derive and use the equation for centripetal force F = mv2/r= mω2r. |  |  |  |
| **6A.09** | Describe simple harmonic motion. |  |  |  |
| **6A.10** | Explain the characteristics of simple harmonic motion. |  |  |  |
| **6A.11** | State the conditions for simple harmonic motion. |  |  |  |
| **6A.12** | Define an equation for simple harmonic motion a = - ω2x and x = A cos 𝜔t and v = ±ω √(A2 − x2) |  |  |  |
|  | ***Sketch the following graphs:*** | | | |
| **6A.13** |          x against t. |  |  |  |
| **6A.14** |          v against t. |  |  |  |
| **6A.15** |          a against t. |  |  |  |
| **6A.16** |          kinetic energy against x. |  |  |  |
| **6A.17** |          kinetic energy against t. |  |  |  |
| **6A.18** |          potential energy against x. |  |  |  |
| **6A.19** |          potential energy against t. |  |  |  |
| **6A.20** |          total energy against x. |  |  |  |
| **6A.21** |          total energy against t. |  |  |  |
| **6A.22** | Appreciate that the v-t graph is derived from the gradient of the x-t graph and that the a-t graph is derived from the gradient of the v-t graph. |  |  |  |
| **6A.23** | Calculate maximum speed using ωA. |  |  |  |
| **6A.24** | Calculate maximum acceleration using ω2A |  |  |  |
| **6A.25** | Study the mass-spring system and use the equation for time period of this system. |  |  |  |
| **6A.26** | Study the simple pendulum and use the equation for time period of this system. |  |  |  |
| **6A.27** | Explain why we use the small angle approximation in the derivation of the time period formula. |  |  |  |
| **6A.28** | Apply simple harmonic motion to other contexts (eg liquid in a U-tube). |  |  |  |
| **6A.29** | Describe the effect of damping on oscillations. , |  |  |  |
| **6A.30** | State what free vibrations mean. |  |  |  |
| **6A.31** | State what is meant by forced vibrations. |  |  |  |
| **6A.32** | State what resonance is. |  |  |  |
| **6A.33** | Describe the effect of damping on the sharpness of resonance. |  |  |  |
| **6A.34** | Apply knowledge of resonance to mechanical systems and situations involving stationary waves. |  |  |  |
| **6A.35** | ***Core Practical: Investigation into simple harmonic motion using a mass-spring system and a simple pendulum.*** | | | |

**A-Level Paper 2 Personal Learning Checklist**

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| **6B. Thermal Energy** | | | | |
| **LO** | **Learning Objectives:** | **Confidence** | | |
|  |  |  |
| **6B.01** | Define internal energy. |  |  |  |
| **6B.02** | Describe how the internal energy of a system can be increased. |  |  |  |
| **6B.03** | Define the first law of thermodynamics. |  |  |  |
| **6B.04** | Explain what happens to a material when it changes state. |  |  |  |
| **6B.05** | Calculations involving transfer of energy. |  |  |  |
| **6B.06** | Define specific heat capacity. |  |  |  |
| **6B.07** | Calculate the energy transferred using Q = mc Δ θ. |  |  |  |
| **6B.08** | Define specific latent heat. |  |  |  |
| **6B.09** | Calculate the energy needed to change state using Q = mL. |  |  |  |
| **6B.10** | State Charles’ law. |  |  |  |
| **6B.11** | State Boyle’s law. |  |  |  |
| **6B.12** | Define the relationship between p, V, T, and the mass of the gas. |  |  |  |
| **6B.13** | Define absolute zero of temperature. |  |  |  |
| **6B.14** | Calculations involving the ideal gas equation: pV = nRT for n moles and pV = NkT for N molecules. |  |  |  |
| **6B.15** | Calculate the work done = p ΔV |  |  |  |
| **6B.16** | Define Avogadro constant. |  |  |  |
| **6B.17** | Define the molar gas constant. |  |  |  |
| **6B.18** | Define Boltzmann constant. |  |  |  |
| **6B.19** | Calculate molar mass and molecular mass. |  |  |  |
| **6B.20** | Describe Brownian motion. |  |  |  |
| **6B.21** | Explain the significance of Brownian motion. |  |  |  |
| **6B.22** | Explain the relationship between p, V and T in terms of a simple molecular model. |  |  |  |
| **6B.23** | Explain why the gas laws are empirical in nature whereas the kinetic theory is not. |  |  |  |
| **6B.24** | Derive pV = ⅓Nm (crms)2 including assumptions made. |  |  |  |
| **6B.25** | Use pV = ⅓Nm (crms)2  in calculations. |  |  |  |
| **6B.26** | Appreciate that the ideal gas internal energy is kinetic energy of the atoms. |  |  |  |
| **6B.27** | Use the average molecular kinetic energy formula. |  |  |  |
| **6B.28** | Appreciate how knowledge and understanding of the behaviour of a gas has changed over time. |  |  |  |
| **6B.29** | ***Core Practical: Investigation of Boyle’s (constant temperature) law and Charles’s (constant pressure) law for a gas.*** | | | |
|  |  |  |  |  |
| **7. Fields** | | | | |
| **LO** | **Learning Objectives:** | **Confidence** | | |
|  |  |  |
| **7.001** | Describe what a force field is. |  |  |  |
| **7.002** | Represent a field. |  |  |  |
| **7.003** | State when a force field can arise. |  |  |  |
| **7.004** | Describe the gravitational force and what particles it affects. |  |  |  |
| **7.005** | State Newton’s law of gravitation in words. |  |  |  |
| **7.006** | Understand and use the gravitational force equation: F = Gm1m2 / r2. |  |  |  |
| **7.007** | Draw a gravitational field around a mass. |  |  |  |
| **7.008** | Define gravitational field. |  |  |  |
| **7.009** | Calculate the magnitude of the gravitational field by using either: g = F/m or g = GM / r |  |  |  |
| **7.010** | Define gravitational potential. |  |  |  |
| **7.011** | State the gravitational potential at infinity. |  |  |  |
| **7.012** | Explain why gravitational potential values are always negative. |  |  |  |
| **7.013** | Understand and use the equation for potential in a radial field: V = -GM / r |  |  |  |
| **7.014** | Sketch a graph of g against r. |  |  |  |
| **7.015** | Deduce what the area under a g against r graph represents. |  |  |  |
| **7.016** | Sketch a graph of V against r. |  |  |  |
| **7.017** | Deduce what the area under a V against r graph represents. |  |  |  |
| **7.018** | State what is meant by the term equipotential. |  |  |  |
| **7.019** | Explain how much work is done when moving along an equipotential surface. |  |  |  |
| **7.020** | Explain how much work is done in moving a mass between two potentials. |  |  |  |
| **7.021** | Calculate the work done in moving a mass between two potentials using: ΔW = mΔV |  |  |  |
| **7.022** | Define gravitational potential energy and how it related to the work done. |  |  |  |
| **7.023** | Explain the relationship between V and g by deriving g = − Δ V/ Δ r. |  |  |  |
| **7.024** | Describe how orbital speed is related to radius of a circular orbit. |  |  |  |
| **7.025** | Describe how orbital period is related to radius of a circular orbit. |  |  |  |
| **7.026** | Derive Keplar’s law: T2 is directly proportional to r3. |  |  |  |
| **7.027** | Describe the total energy, gravitational potential energy and kinetic energy of an orbiting satellite. |  |  |  |
| **7.028** | Define escape velocity. |  |  |  |
| **7.029** | Calculate escape velocity. |  |  |  |
| **7.030** | Define synchronous orbits. |  |  |  |
| **7.031** | Describe a geostationary orbit. |  |  |  |
| **7.032** | Describe a low orbit. |  |  |  |
| **7.033** | Describe some uses of satellites in low obits and geostationary orbits. |  |  |  |
| **7.034** | Describe the similarities and differences between gravitational fields and electric fields. |  |  |  |
| **7.035** | Calculate the force between 2 point charges in a vacuum using the formula: F = 1/(4π ε0) Q1Q2/ r2 |  |  |  |
| **7.036** | State that air can be treated as a vacuum when calculating force between charges. |  |  |  |
| **7.037** | Draw an electric field around a point charge (positive or negative). |  |  |  |
| **7.038** | Draw an electric field around 2 point charges of equal magnitude. |  |  |  |
| **7.039** | Define electric field strength. |  |  |  |
| **7.040** | Calculate electric field strength using both E = F/Q and E = Q/4π ε0r2 |  |  |  |
| **7.041** | Draw a uniform electric field. |  |  |  |
| **7.042** | Calculate the electric field in a uniform using E = V/d. |  |  |  |
| **7.043** | Compare the size of gravitational and electrostatic forces between subatomic particles. |  |  |  |
| **7.044** | Derive a formula for work done in moving a charge between 2 plates: Fd = QΔV |  |  |  |
| **7.045** | Draw the trajectory of a moving charged particle entering a uniform electric field; both parallel and initially at right angles. |  |  |  |
| **7.046** | Describe the motion of a moving charged particle in a uniform electric field. |  |  |  |
| **7.047** | Define electric potential. |  |  |  |
| **7.048** | State the electric potential value at infinity. |  |  |  |
| **7.049** | Define electric potential difference. |  |  |  |
| **7.050** | Deduce whether the electric potential difference is positive or negative. |  |  |  |
| **7.051** | Calculate the work done in moving a charge between two potentials using ΔW = Q ΔV. |  |  |  |
| **7.052** | Calculate the electric potential of a radial field using V = Q/4π ε0r |  |  |  |
| **7.053** | Sketch a graph of E against r. |  |  |  |
| **7.054** | Deduce what the area under an E against r graph represents. |  |  |  |
| **7.055** | Sketch a graph of V against r. |  |  |  |
| **7.056** | Deduce what the gradient of a V against r graph represents. |  |  |  |
| **7.057** | Derive E = Δ V/ Δ r |  |  |  |
| **7.058** | Define capacitance. |  |  |  |
| **7.059** | Calculate capacitance using the equation, C = Q/V. |  |  |  |
| **7.060** | Describe how the size of a capacitor relates to the cross sectional area of the plates, the space between the plates and permittivity of the material between the plates. |  |  |  |
| **7.061** | Describe what a dielectric is. |  |  |  |
| **7.062** | Describe how a dielectric is able to help a capacitor hold charge by explanation of a simple polar molecule. |  |  |  |
| **7.063** | Calculate relative permittivity and the dielectric constant. |  |  |  |
| **7.064** | Explain how a capacitor holds charge. |  |  |  |
| **7.065** | Describe how a capacitor is charged up. |  |  |  |
| **7.066** | Draw graphs relating to the charging of a capacitor (Q-t, V-t and I-t). |  |  |  |
| **7.067** | Explain the shape of the charging graphs. |  |  |  |
| **7.068** | Interpret the gradient and area under each of these graphs. |  |  |  |
| **7.069** | Describe how a capacitor can be discharged. |  |  |  |
| **7.070** | Draw graphs relating to the discharging of a capacitor (Q-t, V-t and I-t) |  |  |  |
| **7.071** | Explain the shape of the discharging graphs. |  |  |  |
| **7.072** | Interpret the gradient and area under each of these graphs. |  |  |  |
| **7.073** | Define time constant, τ. |  |  |  |
| **7.074** | Calculate time constant from the circuit (RC). |  |  |  |
| **7.075** | Determine the time constant from a charging graph. |  |  |  |
| **7.076** | Determine the time constant from a discharging graph. |  |  |  |
| **7.077** | Use and rearrange the equation for capacitor discharge, Q = Q0 e− t/RC. This includes being able to use the natural logarithmic, ln. |  |  |  |
| **7.078** | Use and rearrange the equation for capacitor charge, Q = Q0 (1- e− t/RC). This includes being able to use the natural logarithmic, ln. |  |  |  |
| **7.079** | Derive the time to halve as being T1/2 = 0.69RC. |  |  |  |
| **7.080** | ***Core Practical: Investigation of the charge and discharge of capacitors. Analysis techniques should include log-linear plotting leading to a determination of the time constant RC.*** | | | |
| **7.081** | Define magnetic flux density. |  |  |  |
| **7.082** | Define the tesla. |  |  |  |
| **7.083** | Deduce the direction of magnetic field around a current carrying wire using the right hand grip rule. |  |  |  |
| **7.084** | Deduce the direction of force acting on a current carrying wire in a magnetic field, where the field is perpendicular to the current. |  |  |  |
| **7.085** | Explain why a force is present when a current carrying wire is in a magnetic field. |  |  |  |
| **7.086** | Calculate the force acting on a current carrying wire in a magnetic field using F = BIl |  |  |  |
| **7.087** | Explain how a motor rotates, including the need for a commutator. |  |  |  |
| **7.088** | Calculate the force on a charged particle moving in a magnetic field, F = BQv. |  |  |  |
| **7.089** | Deduce the direction of the force on positive and negative charged particles in a magnetic field. |  |  |  |
| **7.090** | Explain the motion of particles in a magnetic field. |  |  |  |
| **7.091** | Calculate the radius of a particle in a magnetic field using F = BQv and circular motion equations. |  |  |  |
| **7.092** | Explain what happens to the motion of a particle if mass of the particle is changed. |  |  |  |
| **7.093** | Explain what happens to the motion of a particle if the magnetic field is changed. |  |  |  |
| **7.094** | Explain what happens to the motion of a particle if the charge was changed. |  |  |  |
| **7.095** | Describe how a cyclotron works. |  |  |  |
| **7.096** | ***Core Practical: Investigate how the force on a wire varies with flux density, current, and length of wire using a top pan balance.*** | | | |
| **7.097** | Define magnetic flux. |  |  |  |
| **7.098** | Define magnetic flux linkage. |  |  |  |
| **7.099** | Calculate the flux and flux linkage passing through a rectangular coil rotated in a magnetic field using: NΦ = BANcosθ |  |  |  |
| **7.100** | State and apply Faraday’s law. |  |  |  |
| **7.101** | State and apply Lenz’s law. |  |  |  |
| **7.102** | Explain what happens when a straight conductor is moved in a magnetic field. |  |  |  |
| **7.103** | Calculate the emf is induced in a coil rotating uniformly in a magnetic field using: ε = BAN ω sin ωt |  |  |  |
| **7.104** | Describe how an AC generator is different to a dynamo. |  |  |  |
| **7.105** | State what is meant by root mean square voltage/current. |  |  |  |
| **7.106** | State and draw what is meant by peak voltage/current. |  |  |  |
| **7.107** | State and draw what is meant by peak to peak voltage/current. |  |  |  |
| **7.108** | Calculate root mean square current/voltage. |  |  |  |
| **7.109** | Appreciate that main electricity is alternating current and 230V is the r.m.s voltage. |  |  |  |
| **7.110** | Use an oscilloscope to measure ac and dc voltage and time intervals to obtain frequency of ac waveforms. |  |  |  |
| **7.111** | Explain how a transformer works. |  |  |  |
| **7.112** | Understand and use the transformer equation: Ns/Np = Vs/Vp |  |  |  |
| **7.113** | Calculate the efficiency of a transformer: ISVS/ IPVP |  |  |  |
| **7.114** | Explain eddy currents. |  |  |  |
| **7.115** | Describe and explain the causes of inefficiencies in a transformer. |  |  |  |
| **7.116** | Explain why transmission lines require high voltages. |  |  |  |
| **7.117** | Calculate the power loss in transmission lines. |  |  |  |
| **7.118** | ***Core Practical: Investigate, using a search coil and oscilloscope, the effect on magnetic flux linkage of varying the angle between a search coil and magnetic field direction.*** | | | |
|  |  |  |  |  |
| **8. Nuclear** | | | | |
| **LO** | **Learning Objectives:** | **Confidence** | | |
|  |  |  |
| **8.01** | Describe the Rutherford Scattering experiment. |  |  |  |
| **8.02** | Explain the results of the Rutherford Scattering experiment. |  |  |  |
| **8.03** | Appreciate how knowledge and understanding of the structure of the nucleus has changed over time. |  |  |  |
| **8.04** | Describe the properties α, β and γ radiation. |  |  |  |
| **8.05** | Explain how experiments can identify what type of radiation is being emitted. |  |  |  |
| **8.06** | Explain the application of α, β and γ radiation. |  |  |  |
| **8.07** | State the inverse-square law for gamma radiation. |  |  |  |
| **8.08** | Describe an experiment to verify the inverse-square law. |  |  |  |
| **8.09** | State what background radiation is. |  |  |  |
| **8.10** | State examples of the origins of background radiation. |  |  |  |
| **8.11** | Calculate experimental elimination of background radiation |  |  |  |
| **8.12** | Describe the safe handling of radioactive sources. |  |  |  |
| **8.13** | Appreciate the balance between risk and benefits in the uses of radiation in medicine. |  |  |  |
| **8.14** | State the random nature of radioactive decay. |  |  |  |
| **8.15** | Calculate the decay probability of a given nucleus using Δ N / Δt = - λN |  |  |  |
| **8.16** | Calculate and understand using the decay equation: N = N0e-λt |  |  |  |
| **8.17** | State what is meant by activity. |  |  |  |
| **8.18** | Calculate the activity using A = λN. |  |  |  |
| **8.19** | Describe the different models with a constant decay probability. |  |  |  |
| **8.20** | Calculate using molar mass or Avogadro constant. |  |  |  |
| **8.21** | State what is meant by half-life. |  |  |  |
| **8.22** | Calculate half-life using the equation T½ = ln2 / λ |  |  |  |
| **8.23** | Determine half-life from a graphical decay curve. |  |  |  |
| **8.24** | Determine half-life from a graphical log graph. |  |  |  |
| **8.25** | Describe how half-life is important in applications such as radioactive waste and radioactive dating. |  |  |  |
| **8.26** | Draw a graph of N against Z for stable nuclei. |  |  |  |
| **8.27** | Deduce possible decay modes of unstable nuclei including α, β+, β− and electron capture. |  |  |  |
| **8.28** | Represent changes radioactive decay by simple decay equations. |  |  |  |
| **8.29** | Understand nuclear energy level diagrams. |  |  |  |
| **8.30** | Describe what is meant by a nuclear excited state. |  |  |  |
| **8.31** | State what γ ray emission is. |  |  |  |
| **8.32** | Describe applications of γ ray emission, including the use of technetium-99m as a γ source in medical diagnosis. |  |  |  |
| **8.33** | Estimate the radius from closest approach of alpha particles. |  |  |  |
| **8.34** | Determine the radius from electron diffraction. |  |  |  |
| **8.35** | State typical values for nuclear radius. |  |  |  |
| **8.36** | Calculate the radius from nucleon number using R = R0A1/3. |  |  |  |
| **8.37** | State that this equation if derived from experimental data. |  |  |  |
| **8.38** | Interpret the equation as evidence for constant density of nuclear material. |  |  |  |
| **8.39** | Calculations involving nuclear density. |  |  |  |
| **8.40** | Sketch a graph of intensity against angle for electron diffraction by a nucleus. |  |  |  |
| **8.41** | Understand and use E = mc2. |  |  |  |
| **8.42** | Calculate mass difference. |  |  |  |
| **8.43** | Calculate binding energy. |  |  |  |
| **8.44** | State what the atomic mass unit is. |  |  |  |
| **8.45** | Convert between mass difference and binding energy. |  |  |  |
| **8.46** | Describe the process of fission. |  |  |  |
| **8.47** | Describe the process of fusion. |  |  |  |
| **8.48** | Calculate the energy released in fission and fusion reactions from the nuclear mass. |  |  |  |
| **8.49** | Understand and use the graph of average binding energy per nucleon against nucleon number. |  |  |  |
| **8.50** | Identify on the graph, regions where nuclei will release energy when undergoing fission/fusion. |  |  |  |
| **8.51** | Appreciate that knowledge of nuclear energy allows society to use science to inform decision making. |  |  |  |
| **8.52** | Describe how fission is induced. |  |  |  |
| **8.53** | State what is meant by a chain reaction. |  |  |  |
| **8.54** | State what is meant by critical mass. |  |  |  |
|  | ***Explain the functions of the following:*** | | | |
| **8.55** |          moderator |  |  |  |
| **8.56** |          control rods |  |  |  |
| **8.57** |          coolant |  |  |  |
| **8.58** | Understand a simple mechanical model of moderation by elastic collisions. |  |  |  |
| **8.59** | State and describe the factors affecting the choice of materials for the moderator, control rods and coolant. |  |  |  |
| **8.60** | State examples of materials used. |  |  |  |
|  | ***Describe the safety aspects of the following:*** | | | |
| **8.61** |          fuel used. |  |  |  |
| **8.62** |          remote handling of fuel. |  |  |  |
| **8.63** |          shielding. |  |  |  |
| **8.64** |          emergency shut-down. |  |  |  |
| **8.65** |          production. |  |  |  |
| **8.66** |          radioactive waste materials. |  |  |  |
| **8.67** | Appreciate the balance between risk and benefit in the development of nuclear power. |  |  |  |
| **8.68** | ***Core Practical: Investigation of the inverse-square law for gamma radiation.*** | | | |

**A-Level Paper 3 Personal Learning Checklist**

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| --- | --- | --- | --- | --- |
| **A. Practical Skills** | | | | |
| **LO** | **Learning Objectives:** | **Confidence** | | |
|  |  |  |
| A1 | Solve problems set in practical contexts |  |  |  |
| A2 | Apply scientific knowledge to practical contexts |  |  |  |
| A3 | Comment on experimental design |  |  |  |
| A4 | Evaluate scientific methods. |  |  |  |
| A5 | Present data in appropriate ways |  |  |  |
| A6 | Evaluate results. |  |  |  |
| A7 | Draw conclusions with reference to measurement uncertainties and errors. |  |  |  |
| A8 | Identify variables including those that must be controlled |  |  |  |
| A9 | Plot and interpret graphs |  |  |  |
| A10 | Process and analyse data using appropriate mathematical skills as exemplified in the mathematical appendix. |  |  |  |
| A11 | Consider margins of error, accuracy and precision of data |  |  |  |
| A12 | Know and understand how to use a wide range of experimental and practical instruments, equipment and techniques appropriate to the knowledge and understanding included in the specification |  |  |  |
|  | ***Core Practical*** | | | |
|  | Investigation into the variation of the frequency of stationary waves on a string with length, tension and mass per unit length of the string. |  |  |  |
|  | Investigation of interference effects to include the Young’s slit experiment and interference by a diffraction grating. |  |  |  |
|  | Determination of g by a free-fall method |  |  |  |
|  | Determination of the Young modulus by a simple method. |  |  |  |
|  | Determination of resistivity of a wire using a micrometre, ammeter and voltmeter. |  |  |  |
|  | Investigation of the EMF and internal resistance of electric cells and batteries by measuring the variation of the terminal p.d of the cell with current in it. |  |  |  |
|  | Investigation into simple harmonic motion using a mass-spring system and a simple pendulum. |  |  |  |
|  | Investigation of Boyle’s (constant temperature) law and Charles’s (constant pressure) law for a gas. |  |  |  |
|  | Investigation of the charge and discharge of capacitors. Analysis techniques should include log-linear plotting leading to a determination of the time constant RC. |  |  |  |
|  | Investigate how the force on a wire varies with flux density, current and length of wire using a top pan balance. |  |  |  |
|  | Investigate, using a search coil and oscilloscope, the effect on magnetic flux linkage of varying the angle between a search coil and magnetic field direction. |  |  |  |
|  | Investigation of the inverse-square law for gamma radiation. |  |  |  |

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| **12. Turning Points** | | | | |
| **LO** | **Learning Objectives:** | **Confidence** | | |
|  |  |  |
| 12.01 | State what is meant by a cathode ray. |  |  |  |
| 12.02 | Describe the structure of a discharge tube. |  |  |  |
| 12.03 | Explain how cathode rays are produced in a discharge tube. |  |  |  |
| 12.04 | Describe thermionic emission. |  |  |  |
| 12.05 | Calculate the work done in accelerating an electron through a potential difference using 1/mv2 = eV |  |  |  |
| 12.06 | Determine the specific charge of an electron. |  |  |  |
| 12.07 | Explain the significance of Thomson’s determination of the specific charge of an electron. |  |  |  |
| 12.08 | Compare the specific charge of an electron to a hydrogen ion. |  |  |  |
| 12.09 | State the conditions for holding a charged oil droplet stationary between two oppositely charged parallel plates. |  |  |  |
| 12.10 | Understand and use QV / d = mg |  |  |  |
| 12.11 | Describe the motion of a falling oil droplet without an electric field. |  |  |  |
| 12.12 | Describe the motion of a falling oil droplet with an electric field. |  |  |  |
| 12.13 | Use the terminal speed to determine the mass and charge of the droplet. |  |  |  |
| 12.14 | State Stokes’ law. |  |  |  |
| 12.15 | Understand and use F = 6πηrv |  |  |  |
| 12.16 | Explain the significance of Millikan’s results. |  |  |  |
| 12.17 | Explain why charge is considered quantised. |  |  |  |
| 12.18 | State what is meant by wave-particle duality. |  |  |  |
| 12.19 | Describe Huygen’s wave theory in general terms. |  |  |  |
| 12.20 | Describe Newton’s corpuscular theory of the light. |  |  |  |
| 12.21 | Compare Huygen’s wave theory to Newton’s corpuscular theory of light. |  |  |  |
| 12.22 | Explain why Newton’s theory was preferred. |  |  |  |
| 12.23 | Explanation of fringes in Young’s double slit experiment. (No calculations expected here). |  |  |  |
| 12.24 | Explain why there was a delayed acceptance of Huygen’s wave theory of light. |  |  |  |
| 12.25 | Describe the nature of electromagnetic waves. |  |  |  |
| 12.26 | Calculate the speed of electromagnetic waves in a vacuum using Maxwell’s formula: c = 1 / √(m0ε0) |  |  |  |
| 12.27 | Appreciate that m0 relates to the electric field strength due to a charged object in free space and ε0 relates to the magnetic flux density due to a current-carrying wire in free space. |  |  |  |
| 12.28 | Describe how Hertz discovered radio waves. |  |  |  |
| 12.29 | Describe how Hertz was able to take measurements to find the speed of radio waves. |  |  |  |
| 12.30 | Describe Fizeau’s determination of the speed of light |  |  |  |
| 12.31 | Explain the implications of Fizeau’s determination of the speed of light |  |  |  |
| 12.32 | Describe the ultraviolet catastrophe. |  |  |  |
| 12.33 | Describe the black-body radiation. |  |  |  |
| 12.34 | Explain Planck’s interpretation of photoelectricity in terms of quanta. |  |  |  |
| 12.35 | Explain why classical wave theory failed to explain the observations of photoelectricity. |  |  |  |
| 12.36 | Explain Einstein’s explanation of photoelectricity. |  |  |  |
| 12.37 | Describe the significance of Einstein’s explanation of photoelectricity in terms of the nature of electromagnetic radiation. |  |  |  |
| 12.38 | State de Broglie’s hypothesis: p = h / λ; λ = h / √(2meV) |  |  |  |
| 12.39 | Describing low-energy electron diffraction experiments. |  |  |  |
| 12.40 | Explain the effect of a change of electron speed on the diffraction pattern. |  |  |  |
| 12.41 | Estimate the anode voltage needed to produce wavelengths of the order of the size of the atom. |  |  |  |
| 12.42 | Describe the principles of operation of the transmission electron microscope (TEM). |  |  |  |
| 12.43 | Describe the principles of operation of the scanning tunneling microscope (STM). |  |  |  |
| 12.44 | Describe the principles of the Michelson-Morley interferometer. |  |  |  |
| 12.45 | Outline of the experiment as a means of detecting absolute motion. |  |  |  |
| 12.46 | Explain the significance of the failure to detect absolute motion. |  |  |  |
| 12.47 | State the invariance of the speed of light. |  |  |  |
| 12.48 | Describe the concept of an inertial frame of reference. |  |  |  |
| 12.49 | State the two postulates of Einstein’s theory of special relativity. |  |  |  |
| 12.50 | Explain the difference between proper time and time dilation as a consequence of special relativity. |  |  |  |
| 12.51 | Calculate the time dilation using: t = t0 / √ (1 – (v2 / c2)) |  |  |  |
| 12.52 | Describe the evidence for time dilation from muon decay. |  |  |  |
| 12.53 | Calculate length contraction using: l = l0√ (1 – (v2 / c2)) |  |  |  |
| 12.54 | Calculate the equivalence of mass and energy using: E = mc2 and E = m0c2/ √ (1 – (v2 / c2)) |  |  |  |
| 12.55 | Sketch a graph of mass against speed. |  |  |  |
| 12.56 | Sketch a graph of kinetic energy with speed. |  |  |  |
| 12.57 | Describe Bertozzi’s experiment. |  |  |  |
| 12.58 | Explain how Bertozzi’s experiment is direct evidence for the variation of kinetic energy with speed. |  |  |  |