

# VISUAL PHYSICS ONLINE

## CONTENT CHECKLIST

### MY SYLLABUS COMMENTS

The following is a summary of the content covered in the NSW Syllabus for the Australian Curriculum: Physics Stage 6.

When you examine the content, you will discover that a vast number of topics are covered. I have structured the content in a much more orderly fashion than described in the Syllabus. It makes it much easier for students and teachers to assess the content and plan.

#### Students

- You should use the content summary as a **checklist**. For each topic item, you ask yourself a set of questions – What do I know about these topics? What are the key concepts and connections? What physical parameters are involved? What are the equations related to the content?
- To be able to know and understand this immense array of topics, you should make use of [Memory Mind Maps](#) and [Equation Mindmaps](#). The use of mindmaps makes it possible to summarise a large amount of knowledge with a minimum number of words and with the use of vivid images enables you to commit most of this information into your long-term memory.

#### Teachers

- The content summary will make it easier to plan your teaching program and teaching strategies.

## **MODULE 0 WORKING SCIENTIFICALLY**

1. S.I. System of Units.
2. Significant figures.
3. Basic Mathematics: algebraic manipulation of equations, geometry, trigonometry, change of units.
4. Graphs and Graphical Analysis.
5. Measurement: reliability, validity, uncertainty - accuracy (systematic errors) and precision (random errors).
6. Problem Solving Techniques and Skills.

## MODULE 1

## KINEMATICS

1. Identify system to be studied.
2. Frames of reference: inertial and non-inertial frames of reference, Origin, Cartesian coordinate system.
3. Scalars and scalar fields.
4. Vectors and vector fields: vector algebra, addition, subtraction, scalar (dot) product, vector (cross) product, components, unit vectors, vector diagrams.
5. Time, time intervals.
6. Position, distance, displacement.
7. Speed: average and instantaneous.
8. Velocity: average and instantaneous.
9. Acceleration: average and instantaneous.
10. Acceleration: constant (uniformly accelerated motion).
11. Graphical analysis:  $s/t$ ,  $v/t$ ,  $a/t$  graphs.
12. [1D] Linear (rectilinear) motion.
13. [2D] Motion in a plane and projectile motion.
14. Vectors: relative position and relative velocity.

## MODULE 2 DYNAMICS

1. Forces: gravitation, weight, contact forces, normal, friction (coefficients of static and kinetic friction), elastic restoring force, tension.
2. Newton's Laws of Motion (1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup>).
3. Force as a vector: addition, subtraction, components.
4. Free body diagrams.
5. Motion of objects through a resistive medium.
6. Rolling Resistance
7. Torque (vector product), Resultant (net) force, Equilibrium.
8. Momentum, Impulse, F/t graphs.
9. Conservation of Momentum.
10. Work (scalar product), Energy, Kinetic Energy, F/s graphs.
11. Potential Energy (Gravitational, Elastic), Total Energy.
12. Conservation of Energy.
13. Collisions (Elastic and Inelastic) and Explosions.
14. Energy and Power.

## **MODULE 3.1      WAVES**

1. Oscillations (Vibrations), Simple Harmonic Motion.
2. Conservation of Energy: kinetic energy and potential energy.
3. Waves – transfer of energy.
4. Describing waves: wave function, amplitude, wavelength, wave number (propagation constant), period, frequency, angular frequency, speed (propagation velocity).
5. Mechanical waves: sound, earthquakes.
6. Electromagnetic waves: electromagnetic spectrum.
7. Propagation of waves (travelling waves): Transverse and Longitudinal (Compressional).
8. Reflection and Refraction.
9. Superposition Principle: Interference (Constructive and Destructive), Diffraction.
10. Sound waves: longitudinal wave – pressure fluctuations and particle displacement fluctuations, frequency, pitch, amplitude, loudness, power, intensity, inverse square law.
11. Natural frequency of vibration, driving frequency, Resonance.
12. Standing waves: Strings and Air Columns (pipes) – normal modes of vibration, fundamental frequency, harmonic frequencies, overtones.
13. Sound waves: Beats and Doppler Effect.
14. Ray Model of Light: Speed of Light, Reflection, Refraction, Refractive Index, propagation speed in a medium, Snell's Law, Total Internal Reflection, Critical Angle, Dispersion.
15. Ray Model of Light: Image Formation by Mirrors, Image formation by Lenses.
16. Inverse Square Law for light.
17. Polarization.

## **MODULE 3.2      THERMODYNAMICS**

1. Thermodynamics Systems.
2. States of matter (Solid, Liquid, Gases, Plasmas).
3. Temperature (macroscopic and microscopic view).
4. Energy, Work, Heat, Internal Energy, Thermal Energy.
5. First law of Thermodynamics.
6. Specific heat capacity. Conservation of energy: calorimetry.
7. Change of State: latent heats.
8. Methods of Heat Transfer: Conduction, Convection, Radiation.
9. Blackbody Radiation and Wien's Displacement Law.
10. Entropy and the Second Law of Thermodynamics.

## **MODULE 4.1. ELECTRICITY**

1. Structure of the atom: nucleus (proton and neutrons), electrons.
2. Conservation of energy and conservation of charge. Charging of objects – transfer of electrons.
3. Forces between charges: Coulomb's Law.
4. Electric field, Electric field lines. Electric fields and electrical forces.
5. Electric field line patterns: point charge, pairs of charges, dipoles, parallel plate capacitor.
6. Work, energy, charge, potential difference (voltage), emf (electromotive force).
7. Motion of charged particles in electric fields.
8. Electric circuits and energy conversions.
9. Electric current, Resistance, Potential difference.
10. Ohm's Law (ohmic components).
11. Series and Parallel circuits: resistors in series and parallel.
12. Kirchhoff's Current Law (conservation of charge).
13. Kirchhoff's Voltage Law (conservation of energy).
14. Electric energy and power.

## **MODULE 4.1      MAGNETISM**

1. Magnetic force.
2. Magnetic field, magnetic field lines, magnetic flux.
3. Magnetic materials: permanent magnets, ferromagnetic materials, making magnets.
4. Magnetic field produced by currents: straight wires and solenoids (air and ferromagnetic cores).



## MODULE 5

## ADVANCED MECHANICS

1. Circular Motion [2D]: centripetal force and centripetal acceleration, period, angular speed.
2. Gravitational force and Gravitational fields.
3. Newton's Law of Universal Gravitation, gravitational field strength.
4. Motion of objects in gravitational fields [2D].
5. Gravitational potential energy.
6. [2D] Motion: work, energy, kinetic energy, potential energy, total energy, power and conservation of energy.
7. [2D] Motion of planets and satellites: orbital velocity, escape velocity, orbital period, geostationary orbits.
8. Kepler's Laws of planetary motion (1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup>).
9. Projectile Motion [2D].

## MODULE 6

## ELECTROMAGNETISM

1. Electric forces, magnetic forces.
2. Electric fields, magnetic fields.
3. Electric flux and magnetic flux.
4. Motion of charged particles in electric and magnetic fields.
5. Conservation of energy, conservation of charge.
6. Magnetic force on current carrying conductors in magnetic fields.
7. Magnetic force between straight current carrying conductors.
8. How electric and magnetic fields are generated (electromagnetic induction): changing electric flux induces a changing magnetic field. A changing magnetic flux induces a changing electric field.
9. Faradays Law of electromagnetic induction, Lenz's Law, induced emf, induced currents.
10. Transformers.
11. Motor effect: a current element in a magnetic field will experience a force.
12. DC and AC electric motors: construction, torque, back emf.
13. DC and AC generators – induced emfs and induced currents.
14. Magnetic breaking.

## **MODULE 7.1**

### **NATURE OF LIGHT:**

### **ELECTROMAGNETIC RADIATION**

1. Models of light: Newton and Huygens.
2. Electromagnetic Spectrum.
3. Maxwell's theory of electromagnetic waves.
4. Propagation of electromagnetic waves.
5. Historical developments and the speed of light.
6. Wave Model of Light: superposition principle, interference, diffraction – single slit, double slit (Young's double slit experiment), diffraction grating; polarisation, Malus's Law.
7. Particle Model for light: quantum model of light, blackbody radiation, Wien's Displacement law, Planck's contribution to particle nature of light, photon.
8. Particle Model of light: photoelectric effect

## MODEL 7.2

### THEORY OF SPECIAL RELATIVITY

1. Inertial and non-inertial frames of reference
2. Principle of Relativity.
3. Einstein's Postulates: (1) The laws of physics are the same in all inertial frames of reference; (2) The speed of light is a constant and independent of the motion of source or observer.
4. Einstein's thought experiments: simultaneity.
5. Time dilation effect.
6. Length contraction.
7. Relativistic momentum
8. Relativistic energy, total energy, equivalence of energy and mass.
9. Mass / Energy calculations: energy production of Sun, nuclear reactions, chemical reactions, pair production and annihilation.
10. Relativistic addition of velocities.
11. Experimental evidence to support the Theory of Special Relativity: muon decay, atomic clocks (Hafele-Keating Experiment), particle accelerators, cosmological studies.

## **Module 8.1**

### **FROM THE UNIVERSE TO THE ATOM: THE ATOM**

1. Properties of the electron and the atom: cathode ray experiments; Thomson's  $e/m$  experiment, Millikan's oil drop experiment, Geiger-Marsden experiment.
2. Models of the atom: Rutherford and Bohr.
3. The spectrum of the hydrogen atom: line spectra, Rydberg formula.
4. de Broglie matter waves and experimental evidence of matter waves – electron diffraction.
5. Quantum model of the atom: Schrodinger and the wave nature of the electron, concepts of the wave function and probability.

## **Module 8.2**

### **FROM THE UNIVERSE TO THE ATOM: THE NUCLEUS**

1. Models of the nucleus: Chadwick's discovery of the neutron.
2. Nuclear reactions – transmutation of elements: conservation of mass / energy, mass defect, binding energy.
3. Radioactivity: alpha decay, beta decay, gamma decay, half-life, decay constant.
4. Uses of radioactive isotopes.
5. Nuclear fission: uncontrolled (atomic bombs) – chain reactions, controlled (nuclear reactors).
6. Nuclear fusion.
7. Inside the nucleus: protons, neutrons, quarks, the Standard Model, hadrons, leptons.
8. Particle accelerators.
9. Fundamental forces of nature: gravitation, weak nuclear, electromagnetic, strong nuclear.

## **Module 8.3 (Module 7 and Module 8)**

### **Cosmology, Big Bang, Stars**

1. Spectroscopy and the identification of the elements.
2. The Big Bang Theory and the origin of the elements.
3. Doppler Effect for light and the expansion of the Universe, gravitational red shift, Hubble's Law.
4. Electromagnetic spectrum and emission and absorption spectra. Blackbody spectrum.
5. Atomic Spectra: atoms, molecules, discharge tubes, sunlight, reflected sunlight, blackbody radiation (incandescent filaments).
6. Spectra of Stars: surface temperature, Doppler Effect for light, rotational velocity, translation velocity, chemical composition, density.
7. Hertzsprung-Russel diagram and the classification of stars; evolution of stars, surface temperature, colour, luminosity.
8. Energy source of stars: fusion reactions
9. Nucleosynthesis in stars: proton-proton chain, CNO (Carbon-Nitrogen-Oxygen) cycle.

## MY SYLLABUS COMMENTS FOR TEACHERS

From my content summary, you will see that you are expected to cover a very large amount of content in a fixed time period.

Unfortunately, the Syllabus is poorly put together and the organization of the content throughout the Syllabus is appalling. So, you will see that I have introduced sub-modules (e.g. 3.1 Waves and 3.2 Thermodynamics). The introduction of sub-modules will help better organise the content and the teaching of it. The biggest change is the information about stars from Module 7 is moved into Module 8.3. The content related to stars, the Universe, cosmology, Big Bang, origin of the elements becomes the last topic covered. This makes more sense since you need to know about atoms and nuclear process at an earlier stage before tackling things about our Universe.

There is also some content overlap between Years 11 and 12. Where possible it is better to cover these topics in Year 11 in more detailed than would be normally done, so that when you do these topics in Year 12, student have some familiarity with them. If you don't do this, then you will find it difficult to get through all Year 12 topics successfully. For example, in Module 1, in the topic motion in a plane, you are justified to spend some time on projectile motion which is covered in Module 5.



Blackbody radiation is mentioned in a number of modules. You can do a lot on this topic in Module 3.2 (Thermodynamics) when covering the topic on methods of heat transfer – radiation.

The Syllabus gives the indicative hours for modules. You should be flexible in interpreting these hours. For example, I would spend no more than 15 hours on Module 1: Kinematics and no more than 20 hours on Module 2: Dynamics. That is only 35 hours out of the allocated 60. What happens to the other 25 hours? The 25 hours can be done on kinematics and dynamics as you do the other modules. For example, when doing electricity and magnetism you can review many of the topics covered in kinematics and dynamics. This is a better teaching strategy – a quick exposure to a topic and revisiting the topic in small time segments will enable students to get a better grasp of the physics in the long run.

Overall the content covered in the Syllabus is very good, and by going beyond the Syllabus a few times, you should be able to present an exciting, stimulating and useful course to inspire your students.

The Syllabus document is very disappointing in many aspects. The Syllabus may have been appropriate for the 19<sup>th</sup> and 20<sup>th</sup> centuries, but it certainly is not a Syllabus for the 21<sup>th</sup> century. Think about it – 3 out of 8 modules are on mechanics! Mechanics although forms a necessary foundation to physics, it is not the most stimulating or certainly not the one of the most important topics in the 21<sup>st</sup> century.

Only 5% of people who graduate with physics degrees in the U.S.A work as physicist. 95% of graduates are employed in many diverse areas. They are very employable outside physics because of their modelling, mathematical and computing skills. Physics was once broken into experimental and theoretical physics. Today, a category has been added, computational physics. All branches of physics make use of computers and computing modelling and they are of paramount importance. Our prime minister Malcom Turn**bull** spoke of the importance of coding. (The **bull** in Malcom's surname is appropriate). Our “wonderfully bad” new syllabus has left us in the dark-ages.

I would encourage all teachers to use Matlab as a coding and simulation tool. It is one of the leading software package used by scientists and engineers throughout the world. If not Matlab, you can still do amazing things in a spreadsheet such as MS Excel.

Writing the code to stimulate a physical phenomenon is often a more successful way to gain insight into the physics than traditional physics problems and using a simulation. Using a package such as Matlab you are giving skills to your students that may be even more valuable to students than the physics.

From the very start of your teaching of Year 11 Physics, you should encourage students to develop good habits. You should look carefully at my notes in Module 0 (Working Scientifically) which discuss many of those good practices.

Make your teaching more interactive and not teacher centred. Make more use of group work with teams of three students (3 better than 2). Constructing mindmaps and doing exercise together is much better than student passively copying notes from the blackboard.

### [VISUAL PHYSICS ONLINE](#)

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