NSW INDEPENDENT TRIAL EXAMS
PHYSICS – HSC TRIAL - 2006
MARKING GUIDELINES

Section I

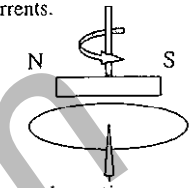
Part A

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
C	D	B	C	A	D	C	A	D	B	B	A	D	A	B

Part B

16. (a) $s = ut+\frac{1}{2}at^2 \Rightarrow 0.90 = 0+\frac{1}{2}x9.8xt^2 \Rightarrow t = 0.43s$ $d = u_x t = 2.6m$
    (b) At time T, ball B is level with Ball A but has moved 2 more units across.
    (c) At time 3T, ball A is 18 units below position at t = 0
17. (a) The g-force scale is a relative scale. Measurement of the force acting on an object is expressed in multiples of the objects weight at sea level.
    (b) Astronauts lie horizontally facing upwards.
18. (a) $v = \sqrt{(Gm_{Earth}/r)} = \sqrt{6.67 \times 10^{-11} \times 6.0 \times 10^{24} \div 6.38 \times 10^{6}} = 6.5 \times 10^{3}\ ms^{-1}$
    (b) The orbital speed is the same, as mass is not used to calculate its speed.
19. The principle of simultaneity states that two events which appear simultaneous in one frame of reference may not appear simultaneous in a different frame of reference. For example, two exploding stars may be observed to appear in the night sky at the same instant of time by an astronomer on earth, but an observer in a different part of the galaxy may notice that the star furthest from earth actually exploded many thousand of years before the star closest to earth.
20. (a) Experiments had shown that light was a wave and all other known waves required a medium for transmission so they assumed that light too would need a medium.
    (b) It is now known that the speed of light is independent of the motion of the observer. So any "race" between rays of light travelling across or into any "aether" will never produce a winner that could be detected by changes in an interference pattern. Sound and water waves, on the other hand, have a constant speed relative to the medium in which they are travelling and any similar "race" using sound or water would produce a clear winner.
21. Time dilation effects mean that space travel at speeds approaching that of the speed of light would be more viable than at the slower speeds we are capable of at present because long journeys could conceivably be made within a reasonable time as far as the astronaut is concerned. This has positive implications for food, water and air resources and for the psychological well being of the astronauts.
    However, the fuel needed to accelerate the spacecraft to near light speeds, particularly given the mass increase that accompanies this means that it is improbable with current technology, to attain these speeds.
22. (a) $F = nBIL \Rightarrow 1.9 - 1.6 = 100 \times B \times 0.2 \times 0.05 \Rightarrow B = 0.3T$
    (b) From P to Q
    (c) 2.3A
    (d) When the current through the coil is altered, the force on the coil will vary and cause the coil to hang in a different position between the magnetic poles and not be subject to the same magnetic field. By ensuring that the coil experiences the same magnetic field, I = (Force reading – 0.16)/1.5.
23. DC systems have considerable energy losses in transmission and generating systems are more complex and expensive. DC transmission is limited to shorter distances than AC. Energy losses in transmission lines are determined by the power formula $P = I^2 R$ where I is current flowing and R is total resistance. This indicates that energy loss increases with distance and greatly increases with current. Therefore it is best to transmit at low current and at a high voltage so that the needed power level is still available to the user. (Power transmitted = IV). This is easily accomplished in AC systems using transformers.

24. (a) $V_p / 60 = 14 / 28 \Rightarrow V_p = 30V$
    (b) The emf generated is proportional to the rate of change of flux. So when the flux is changing most rapidly the emf is a maximum and when there is zero change in flux the emf is zero.
    (c) The heating effect of the eddy currents are greatly reduced by 1. the use of a laminated core, made up of thin sheets insulated from each other to greatly reduce eddy currents; and 2. the use of cores made of ferrites, complex oxides of iron and other metals that are ferromagnetic but have much greater resistance than pure iron and this also reduces eddy currents.
25. (a) Any suitable method such as rotating a magnet close to an aluminium or copper disc that is also free to rotate. The disc will begin to rotate in the same direction as the magnet because of eddy currents induced in it.



    (b) The coils in the cooking plate produce high frequency alternating magnetic fields set up by high frequency alternating currents. The magnetic fields flow through the iron cookware and produce eddy currents in it, causing heating. This effect also occurs in other conducting metals such as copper but due to low resistance, the heating effect is minimal. Hence iron saucepans are recommended.
26. The high voltage must be supplied to the electron gun where electrons are produced by thermionic emission and accelerated towards the screen. The electron beam is deflected horizontally and vertically using the electric field between parallel plates and these do not require as high a voltage.
27. A maglev train moves along a guideway that uses electromagnets to produce magnetic fields for suspension and other coils for guidance and propulsion. Because the normal friction with rails is eliminated, very large speeds can be achieved by trains of streamlined design.
    Since powerful magnetic fields in both the vehicle and the guideways are required, superconducting electromagnets are more energy efficient but achieving the needed low temperature is difficult. As researchers discover materials that become superconductors at ever higher temperatures, the economics of building maglev trains will result in their increased use.
28. (a) Hertz set up a high alternating voltage between a small gap to produce a fast changing electric field, causing a spark to cross the gap. He reasoned that the changing electric field would set up a changing magnetic field and produce electromagnetic waves as predicted by Maxwell's theory. The receiver was a metal loop with a gap and he observed sparks in this loop whenever the spark oscillated across the high voltage gap.
    (b) Hertz used interference between the wave moving directly to the receiver and part of the same wave reflected by a metal plate to measure the wavelength. The frequency of the wave was the frequency of the alternating high voltage source. Speed = $f\lambda$ He found that the speed was as predicted by Maxwell and matched the known speed of light.
    His experiments also related radio waves to light waves by showing that they had the same properties such as reflection, refraction, diffraction and polarisation.
    (c) These experiments were evidence for the electromagnetic waves described by Maxwell's equations and for the electromagnetic nature of light waves. This resulted in the prediction of e/m waves of different frequencies. The waves produced by Hertz became known as radio waves and his method became the basis of producing waves of precise frequencies. Electromagnetic waves of varying frequencies are the basis of modern communication technology and therefore his work was very important.
29. Thermionic devices have many shortcomings. They are large and require a high voltage, are fragile since they use evacuated glass tubes; they need heat sources that consume large amounts of energy and produce heat that damages other circuit elements; they are unreliable, and expensive to produce.
    Solid state devices (transistors, diodes, integrated circuits) replaced thermionic devices because they do not have these failings.
    Society today relies on many appliances using integrated circuits for communication, entertainment, medicine, business, travel and defence. This results in a high standard of living, with cheap communication and travel, effective health care and a variety of accessible leisure/entertainment activities based on computer technology.

Question 33 - From Quanta to Quarks

(a) (i) Rutherford proposed that the atom had a very dense, positive nucleus with electrons around it. The model could not explain anything about the behaviour of the electrons. Previous models did not separate the positive and negative charges inside the atom (Thompson's plum pudding model in which electrons were embedded in a sphere of positive matter).

(ii) Bohr proposed that the electrons were in stable orbits that did not radiate energy as other accelerated charges do. The stable orbits were quantised.

(b) $\frac{1}{\lambda} = R_H\left(\frac{1}{2^2} - \frac{1}{n^2}\right)$ where $n \geq 3$

(c) In 1925, Heisenberg developed his mathematical theory of quantum mechanics. He proposed that uncertainty is an inherent property of quantum mechanics showing that there are pairs of properties that cannot be determined simultaneously (eg position and velocity).
Pauli applied the new quantum mechanics to the hydrogen atom. He stated the Pauli Exclusion Principle: in an atom, no two electrons could have the same set of four quantum numbers. His work allowed chemists to work out the electronic configurations for elements in the Periodic table and explain the groupings of the elements.

(d) In an uncontrolled nuclear chain reaction, the fissionable material exceeds the "critical mass". In this case, the rate of producing neutrons exceeds the rate at which they are lost from the mass resulting in an explosion.
In a controlled chain reaction, the rate of neutron production and loss is such that for every fission, there is on the average, one neutron available to cause another fission reaction. Neutrons are lost mainly by absorption in the control rods.

(e) (i) A cloud chamber consists of a sealed container with a hole to insert the radioactive source and a layer of alcohol (often a ring of material soaked in alcohol). Under the chamber is a compartment for crushed "dry ice" that cools the chamber above. The alcohol evaporates and a cooled supersaturated alcohol vapour exists in the chamber. When the radioactive source is introduced at one side of the chamber, the vapour condenses into visible drops around any charged particles. As the radiation from various sources move across the chamber, it ionises the air in the chamber and leaves a trail of drops along its path.
The number of trails observed in the cloud chamber depends on the level of activity of a radioactive isotope as well as the amount of alcohol vapour remaining in the chamber and the temperature.
Therefore the validity of its use to compare the level of activity of two sources is questionable as saturation and temperature decrease with time.

(ii) The radioactive isotope must have been part of a radioactive decay series, decaying to other radioactive isotopes with shorter half-lives so that the activity level is increased.

(f) The current model, known as the Standard Model, describes two major groups of sub atomic particles: the matter particles (fermions) and the force carriers (bosons).
Fermions are quarks, electrons and neutrinos and combinations of these make up protons and neutrons. The bosons mediate the forces between particles (photons for electromagnetism, the W and Z bosons for the weak force, and gluons for the strong force).
Accelerators are devices in which charged particles can be accelerated to high kinetic energies and are then made to collide with other matter (neutrons, protons, electrons, nuclei etc) to liberate the smaller particles that are described in the Standard Model.
Designs today allow energies of 7 TeV to be achieved and to collide protons travelling in opposite directions. It is through such use of accelerators that physicists have accumulated evidence that confirms the Standard Model of matter.

Question 34 - The Age of Silicon

(a) (i) Electric circuits are connections of conducting wires and other devices through which the uniform flow of electrons occurs and electrical energy is usually transformed into some other kind of energy. In electronic circuits some means of *control* is exerted over the flow of electrons by another electrical signal, and the circuits are generally used to carry and process electric signals.

(ii) An electronic circuit using solid state devices operates at low voltages and therefore cannot directly control large currents or high voltages common in circuits connected to 240V. A relay is placed at the output of a controlling electronic circuit and its mechanical contacts are used to switch the mains circuit.

Question 34 continues on the next page

Marks

Question 16 (3 marks)

When the orbit of a satellite decays, its gravitational potential energy decreases. Explain this in terms of the Law of Conservation of Energy. 3

Criteria	Marks
States that as E_P decreases the E_K increases as the satellite is moving faster so that Law of Conservation of Energy is obeyed as energy is changed from one form to another.	3
States that as E_P decreases the E_K increases as the satellite is moving faster so that Law of Conservation of Energy	2
States that as E_P decreases the E_K increases as the satellite	1

Marks

Question 17 (3 marks)

(a) Explain the concept of *g-force*. 2

Criteria	Marks
States that g-force is a relative scale expressed in multiples of acceleration dues to gravity	2
States that g-force expressed in multiples of acceleration dues to gravity	1

(b) Recall one strategy used during rocket takeoff to minimise the g-force acting on astronauts. 1

Criteria	Marks
States that astronauts take off in a lateral (lying down) position	1

Question 18 (4 marks)

A satellite has a mass of 250 kg and orbits the Earth at an altitude of 3000 km. Earth's equatorial diameter is 12 756 km.

(a) Determine its orbital speed. 2

Criteria	Marks
Uses $v = \sqrt{(Gm_{earth}/r)}$ to obtain 6.5×10^3 ms^{-1}	2
Attempts to derive $v = \sqrt{(Gm_{earth}/r)}$ to find velocity	1

Question 24 (4 marks)

The transformer below has 14 turns in the primary coil and 28 turns in its secondary coil. The graph shows how the flux in the iron core of the transformer is related to the emf and current induced in the secondary coil.

(a) If the voltage across the secondary coil is 60 volts, what is the input voltage? 1

Criteria	Marks
States $V_p = 30$ V	1

(b) The graph shows that the emf across the secondary coil is a maximum when the flux through the iron core is zero. Explain this relationship. 1

Criteria	Marks
States that emf is proportional to change of flux because the greatest change in the flux is when emf is zero	1

(c) Explain how the heating problems of transformer cores are overcome. 2

Criteria	Marks
Use of laminated coil to reduce eddy currents AND Oil cooled transformers to remove heat OR Use of iron oxides which are ferromagnetic but do not produce the same amount of eddy curents	2
One of the above	1

Question 25 (6 marks)

Induction has many applications, being used in a number of electrical devices.

(a) Describe an investigation performed in a school laboratory to demonstrate the principle of an AC induction motor. 3

Criteria	Marks
Clear description of rotating magnetic field causing the metal to rotate without any electrical connection	3
Basic description of rotating magnetic field causing the metal to rotate without any electrical connection	2
Limited description of rotating magnetic field causing the metal to rotate without any electrical connection	1

(b) Manufacturers state that induction cooktops can only be used with saucepans made from iron and purchasers are advised to use a refrigerator magnet to test their saucepans.

Since currents can be induced in metals other than iron, discuss the reasons for designing induction cooktops that require iron based saucepans. 3

Criteria	Marks
Clear description of changing magnetic field causing eddy currents to be induced and that the relatively high resistance of iron compared to copper means that more heat is generated	3
Basic description of changing magnetic field causing eddy currents to be induced and that the relatively high resistance of iron compared to copper means that more heat is generated	2
Limited description of changing magnetic field causing eddy currents to be induced and that the relatively high resistance of iron compared to copper means that more heat is generated	1

Question 26 (4 marks)

Explain the need for both a high voltage and a lower voltage in different parts of a cathode ray oscilloscope. 4

Criteria	Marks
States that a high voltage is needed in the electron gun to accelerate the electrons and that a lower voltage is needed to deflect the beam horizontally and vertically.	4
Describes high voltage in the electron gun and the low voltage in the deflecting plates	3
Distinguishes between electron gun and deflecting plates	2
States that the electron gun accelerate the electrons OR Deflecting plates move the beam of electrons	1

Question 27 (2 marks)

State the advantages of the maglev train and explain the impact of superconductors on the development of this mode of transportation. 2

Criteria	Marks
States that maglev trains move at high speed due to low friction AND These only exist because superconductors have zero resistance below critical temp. they are efficient users of energy	2
States one of the above	1

Question 28 (7 marks)

In the1860's, Maxwell developed his famous equations describing the interaction of magnetic and electric fields resulting in the production of self-propagating "electromagnetic" waves.

(a) Outline the experiment performed by Hertz producing electromagnetic waves. (You may use a labelled diagram.) 2

Criteria	Marks
Describes Hertz apparatus including spark gap and detecting loop.	2
Attempts to describes Hertz apparatus including spark gap or detecting loop.	1

(b) Explain how Hertz confirmed that his waves were the electromagnetic waves predicted by Maxwell's equations and that they had the same properties as light. 3

Criteria	Marks
Describes how Hertz used interference patterns to find the speed AND This speed was same as for light AND These waves could be reflected, polarised etc like light waves	3
Any two of the above	2
Any one of the above	1

(c) Evaluate the importance of the experiments performed by Hertz to scientific theory and society. 2

Criteria	Marks
States the importance to scientific theory as the experiments backed up the theory and led to the discovery of other em waves AND Formed the basis for all modern communication using radio, TV etc waves	2
Any one of the above	1

Question 29 (7 marks)

Discuss the replacement of thermionic devices by solid state devices and assess the impact of solid state devices on society and modern technologies. 7

Criteria	Marks
Well constructed extensive answer describing the shortcomings of thermionic devices AND Well constructed extensive answer describing the advantages of solid state devices AND Makes a judgment on the impact on society and modern technologies of solid state devices	7
Sound answer describing the shortcomings of thermionic devices AND Sound answer describing the advantages of solid state devices AND Makes a judgment on the impact on society and modern technologies of solid state devices	5-6
Sound answer describing the shortcomings of thermionic devices OR Sound answer describing the advantages of solid state devices AND Makes a judgment on the impact on society or modern technologies of solid state devices	3-4
Limited answer describing the shortcomings of thermionic devices OR Sound answer describing the advantages of solid state devices OR Makes a judgment on the impact on society or modern technologies of solid state devices	1-2