NSW INDEPENDENT TRIAL EXAMS – 2001
PHYSICS - SUGGESTED ANSWERS

SECTION I - PART A

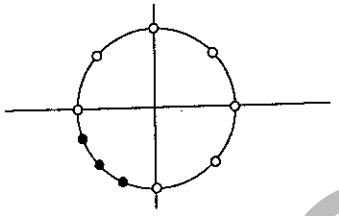
1 C	2 B	3 A	4 D	5 B	6 A	7 D	8 D	9 C	10 D
11 A	12 B	13 D	14 C	15 B					

SECTION I - PART B

16. (a) Geostationary: very distant from Earth; stays above one point of the Earth's equator (orbital period 24 hours); Low Earth Orbit: close to the Earth; orbital period approx 2 hours; not confined to equatorial plane.
    (b) always in communication with at least one land based receiving station.
    (c) Remote sensing (closer to Earth's surface = better resolution) OR Parking orbit (orbital parameters can be accurately determined prior to further rocket firings).
    (d) Advise the public, try to control crash site to uninhabited regions.

17. Description should be of a conservation of angular momentum experiment such as whirling a mass on a string and shortening the string. A description of increase in linear speed should be included. The result could be tested by comparing information about orbital distances and periods for known satellites.

18. (a) 12 hours (b)



    (c) Effective heat shield – to protect astronauts from very high temperatures; retarding rockets to reduce re-entry speed; ablation layer – to carry off excess heat.

19. (a) Two belts of energetic charged particles (electrons and protons).
    (b) The belts shield the Earth from the solar wind and its charged particles.
    (c) Sunspots produce outbursts of charged particles and these interact with those in the Van Allen belt producing changes within them.
    (d) The drift of particles within the Van Allen belts is a ring current with an associated magnetic field. Changes in the belts can produce an increase of up to 25 times in this field once or twice a month leading to interference with communications.

20. Two such experiments are: analysis of the flight distance of muons created in the upper atmosphere – they travel much further than their rest velocity half life would indicate so their clocks must be running slow; OR comparison of two atomic clocks one stationary on the surface, the other taken for a ride on a jet aircraft. This second experiment actually requires application of the General Theory for a proper explanation.

21. The plane of laminations is normal to the direction of eddy currents and so the insulation reduces eddy currents to insignificant values.

22. (a) Nm (newton.metre). (b) $\tau = BIAN \Rightarrow 0.009 = 0.1 \times 0.75 \times 0.02 \times 0.06 \times N$
    $N = 100$ turns

23. Field coils rotate – (low current) reduces sparking
    More than one armature coil = greater emf
    Sets of armature coils = multiple phases possible as output.

24. At P the field is to the right and stronger than at Q where the field is to the left.

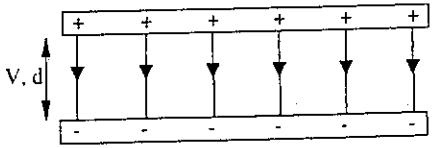
25. (a) Following the generator is a step-up transformer to the transmission lines to a distant sub-station. This increases the voltage and reduces the current so that the product VI is a constant. Following the sub-station there can be a number of step-down transformers (reducing V and increasing I) until the consumer who receives the power at 240 V.
    (b) The main source of loss are resistive losses $\propto I^2$. So by reducing I, losses are minimised.

26. Three of: more turns; faster removal; increase area of coil; strengthen magnetic field.

27. (a) There is a phase difference between them.
    (b) Induction motors are simple, with no power being supplied to the rotating core; they have high efficiency and low cost.

28. (a) (i) Cathode rays are electrons (negatively charged) so are attracted to the positive plate and repelled by the negative plate and hence original path is diverted to E;
    A charge moving in a magnetic field has a force on it, hence original path is diverted to M.
    Diverting forces are equal and opposite so there is no diversion.
    (ii) $F_{magnetic} = F_{centripetal} \Rightarrow Bqv = mv^2/r \Rightarrow q/m = v/Br$
    $F_{electric} = F_{magnetic} \Rightarrow Eq = Bqv \Rightarrow v = E/B$
    $\frac{q}{m} = \frac{E}{B^2 r}$ Since E, B and r are measurable, $\frac{q}{m}$ can be determined
    (b) CRO uses internal deflection plates (electric forces) whereas TV uses external steering coils (magnetic forces).

29. (a)



positive plate
electric field lines
negative plate

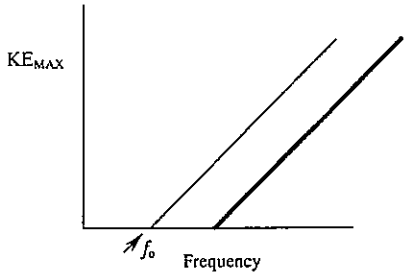
    (b) $E = V/d = 2000 \div 1.5 \times 10^{-2} = 133{,}333\ Vm^{-1}$

30. $F = Bqv = 0.5 \times 1.6 \times 10^{-19} \times 10^{3} = 8 \times 10^{-17}$ N up out of paper

31. $E = hf = 6.625 \times 10^{-34} \times (3 \times 10^{8} \div 1.6 \times 10^{-7}) = 1.24 \times 10^{-18}$ J

32. Silicon can be doped by adding about one part per million of another element. If the additive comes from group III on the periodic table one electron is missing from the bond and so a "hole" exists. If the additive comes from group V an extra electron is present. The first is called P type because the hole can act as a positive charge carrier and the second is called N type as the electron is a negative charge carrier.

33. (a) The photoelectric effect is the ejection of electrons from metal surfaces by electromagnetic radiation (typically in the UV region of the e-m spectrum).
(b) Energy of a quantum of light is E = hf; all this energy is transferred to an electron.



QUESTION 34 – GEOPHYSICS (NO OPTION RELEASED AT THIS TIME)

QUESTION 37 – QUANTUM TO QUARKS

(a) (i)

(ii) Since hydrogen is the simplest atom, its emission spectrum should also be the simplest and so was of great interest in the developing ideas about the structure of the atom. Max Planck's quantisation of oscillators for blackbody radiation was used by Einstein to explain the photoelectric effect and was vital for Bohr's model of the atom in which he quantised angular momentum of electrons.

(iii) $\frac{1}{\lambda} = R\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right) = 1.097 \times 10^{7}\left(\frac{1}{2^2} - \frac{1}{4^2}\right) = 2.057 \times 10^{6}\, m^{-1} \therefore \lambda = 4.86 \times 10^{-7}\, m$

(b) (i) De Broglie postulated that particles could have a wavelength associated with their momentum (analogous to photons having a momentum associated with their wavelength).
(ii) Electron orbits can be considered to be stable if they contain a standing wave – the electron being considered as a wave. This immediately implies quantisation, as only integral multiples of wavelengths can form such standing waves.
(iii) Davisson and Germer demonstrated that electrons scattered from a nickel crystal had a distinct interference pattern – such being a wave property, not a particle property. De Broglie's postulate was confirmed.

(c) (i) An electron microscope has greater resolving power (this determines the smallest angular separation of objects that can be distinguished) than a light microscope because resolving power is proportional to the wavelength of the waves being used, and the wavelength of an electron is very much smaller than that of light – consequently the angular separation that can be determined is much smaller for an electron microscope.
(ii) Light microscopes allowed individual cells and even contents to be studied, and showed a tiny world of living things. These advances had a huge effect on medicine and hygiene. The electron microscope allowed cell structures to be studied thus assisting further in the knowledge of cellular processes.

(d) (i) $^{235}U_{92} + {}^{1}n_o \rightarrow {}^{141}Ba_{56} + {}^{92}Kr_{36} + 3\,{}^{1}n_o + E$
initial mass = 235.0439 + 1.0087 = 236.0526 u
final mass = 140.9137 + 91.8973 + 3× 1.0087 = 232.8112 u
Mass defect = 0.2153 u = 0.2153 × 931.5 = 200.6 MeV.
(ii) eg: Americium 241 in smoke detectors.

(e) Rutherford's model of the atom consisted of a tiny, massive, positive nucleus with negative charge (electrons) somewhere outside it. Today's model in simplest form, follows the combination of De Broglie and Bohr – as for Rutherford but with the electrons in defined orbits around the nucleus – the electrons occupying well-defined energy states.