TRIAL EXAMS - 2004

PHYSICS

SUGGESTED ANSWERS

Section I
Part A

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

Part B

16. (a) $v = u + at = 0 + 9.8 \times 15 = 147\ ms^{-1}$ 2
(b) $\Delta y = u_y + ½a_yt^2 = 0 + ½ \times 9.8 \times 15^2 = 1{,}102.5\ m$ 2

17. (a) Orbital decay is the loss of orbit altitude of a satellite when circling the Earth. 1
(b) Increasing atmospheric drag due to increasing atmospheric density; increasing gravitational force due to decreasing altitude. 1 ea.(2mks)

18. (a) 0.57 seconds^2 1
(b) Using the formula $T = 2\pi\sqrt{L/g}$ and squaring both sides, the slope of the graph is seen to equal T^2/L which is also equal to $4\pi^2/g$. Knowing the slope and the value of π, the value of acceleration due to gravity can be determined. 2
(c) $T^2 = 4\pi^2 \frac{L}{g}$; $g = \frac{4\pi^2}{4.2} = 9.4\ ms^{-2}$ 1 ea.(2mks)
(d) The lower value of "g" as determined by the experiment indicates that the experiment was performed at a high altitude. 1

Criteria:

19 (a) •Clearly distinguishes both types of frames (perhaps with examples) 2
•Poorly explained or confused yet correct statements about the two types of frames 1
(b) •Correct answer including unit (2.529 × 10-27 kg) 2
•Gets mass of proton and speed of light from data sheet and attempts to use correct equation. Makes an error but still has an answer heavier than the rest mass of a proton 1
(c) •Clearly identifies and discusses one of time, length or mass and correctly indicates what happens to this dimension when it is travelling at very high speeds. Gives examples of evidence for the chosen dimension 3
•Gives example, poorly identifies relationship to experiment 2
•Gives example, does not successfully relate to experimental evidence 1

20. (a) Explains how eddy currents are generated 1
Gives reasons for eddy current production 1
Identifies that eddy currents obey Lenz's Law – causing slowing of fall rate 1
(b) Gives clear account of how eddy currents are produced in some other application associated with the slowing of a moving body, eg: amusement park rides. 2

21. Answers could include the following points: 6

- Edison produced D.C. which is very good for running motors but struggles with long distance transmission problems. Power loss, can't change the voltage etc
- Westinghouse produced A.C. which can change voltage easily but without A.C. motors was not nearly as useful.
- Westinghouse realized the invention by Tesla (who had been working for Edison!!) of the A.C. motor would give him the edge. Westinghouse purchased the patent from Tesla and won the contract to harness Niagara.
- Bitterness of the feud; AC is superior (because ease of production of high voltages, distance of transmission, etc)
- Edison's D.C. generation systems quickly disappeared.

22. (a) •Explains voice coil produces own field
•Motor effect – motion to and fro, with changes in coil current 2
(b) •Explains motion of current-carrying coil in magnetic field
•Describes use/application of motor effect 2

23. (a) Eddy currents cause the heat problem; insulated laminations help minimise it. 2
(b) Gives an example of, and correctly identifies appliances with reasons for the use. eg step-up transformer in TV set to provide high voltages for the picture tube; step-down transformer for radio/computer semiconductors that work on low voltages. 3

24. (a) Sample answers: 2

- **travel in straight lines**: a 'Maltese Cross' type discharge tube (appropriate diagram would be good)
- **the rays are able to transfer energy and do work**: a 'paddle wheel' type discharge tube (with diagram)

(b) Maltese cross: When the cross is not erect, but lying flat down, the end of the glass tube opposite the cathode fluoresces. When the cross is erect, the cross casts a sharp shadow at the end of the tube. The sharp shadow indicates straight line travel.
Paddle wheel: On the start of discharge, with the wheel positioned at the cathode end of the tube, it rotates and rolls towards the opposite end of the tube. Since the moving wheel has gained kinetic energy, work has been done by the cathode rays and they have transferred energy. 2

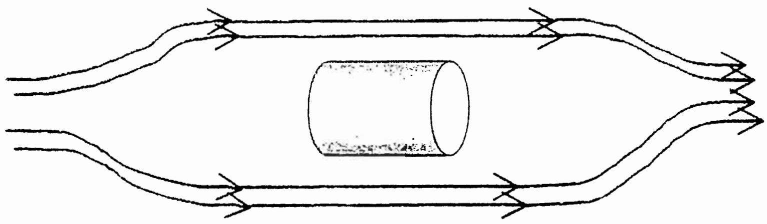
Criteria:

25. Clear explanation of at least three observations of the photoelectric effect using Einstein's ideas (i.e. Planck's quanta). 5-6
Clear explanation of two observations, or for a lesser quality explanation of three observations or for identifying 1 or 2 observations and explaining one only. 3-4
Explanation of one observation, or for identifying 1 or 2 observations 1-2

26. (a) Pure silicon is a sample of silicon i.e. all the atoms present are silicon atoms. Doped silicon is a sample of silicon in which either another element from Group III or V has been added as an impurity in a concentration of about one atom in 200,000 silicon atoms. 2
(b) From the table, doped silicon is 100 times less resistive/more conductive than pure silicon. If silicon is doped with a Group V element, four of the five valence electrons bond into the silicon lattice – the fifth remains unbound and is free to move, contributing to conduction. 4

27. (a) Equal and opposite force vectors (mg downwards, magnetic repulsion up) 1 ea.(2mks)

(b) (i) 1



(ii) Electric currents, flowing in the superconductor in its superconducting state, produce a magnetic field that cancels the applied magnetic field inside the conductor, such that the net magnetic field is zero. 2

SECTION II

Q31 From Quanta to Quarks

(a) (i) A high voltage from an induction coil is passed across a glass tube containing hydrogen gas at low pressure and viewed through a spectroscope in a darkened lab. A line emission spectrum is seen, consisting of a red line, green line and blue line. 2

(ii) $\frac{1}{\lambda} = R\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$ $1/\lambda = 1.097\times10^7\ (1/4 - 1/16) \Rightarrow \lambda = 4.9 \times 10^{-7}$m 2

(iii) For jumps into third energy level , $n_f = 3$ and $1/ n_f$ will be less. This results in a higher wavelength the value on the right side of the formula is inverted. Higher wavelength (and smaller frequency) means that the radiation is in the infra-red range. 3

(b) (i) Diffraction is the spreading of waves around corners or through small openings. 1

(ii) Following the application of Planck's hypothesis to the photoelectric effect by Einstein, de Broglie reversed the idea and applied the wave model to particles, considering them as wave packets. He had been grappling with the question of why Bohr's postulates applied to the electron orbits in his doctoral thesis and came up with his extraordinarily peculiar explanation that particles had a wave nature. There was no experimental evidence for his hypothesis.
He suggested that $\lambda = h / mv$ where mv is the momentum of the electron, λ its wavelength and h is Planck's constant. Other physicists laughed when they heard it and he almost failed to get his degree until it was sent to Einstein who was so impressed that he wrote an introduction. Soon afterwards his hypothesis was experimentally verified and within a few years, the wave hypothesis of de Broglie was developed by Heisenberg, Schrödinger and others into a complete theory of quantum mechanics that replaced classical physics. 3

(c) (i) A moderator slows the fast neutrons to avoid capture by U-238. U-238 either absorbs faster neutrons or undergoes fission but does not produce sufficient neutrons to reliably sustain a chain reaction. A moderator is made from material of low mass number so that the kinetic energy of the neutrons is transferred from the neutrons in collisions with the atoms of the moderator. 2

(ii) Accelerators are devices in which charged particles can be accelerated to high kinetic energies. These particles, moving at close to the speed of light, are made to collide with the nucleus of atoms to cause fission or with neutrons and protons to liberate smaller particles.
Collisions with other nuclei produces radioactive isotopes that are used in medicine, agriculture and engineering. In medicine, radioisotopes kill cancer cells and are used in diagnostic tests. These isotopes could not be imported as their half-lives must be short and therefore the accelerator has to be built near the hospital where they are used.
Physicists use the high energy particles to probe nuclear particles and this has resulted in the current "standard model of matter". This states that protons and neutrons are not fundamental particles but made up of quarks. A large number of subatomic particles have been identified.
While the value of isotopes in medicine is obvious and the usefulness of other applications also accepted, it could be argued that the benefits of understanding the structure of matter is doubtful and that the cost of building bigger and faster accelerators is unjustified. However, it is usually many years after new knowledge is discovered that its potential benefits are realised. 4

(d) Bohr produced a theoretical model of the atom that accounted for the stability of electrons in their orbits and the production of a line spectrum rather a continuous spectrum. In his mathematical analysis, he used Planck's hypothesis, successfully applied by Einstein, and derived a formula for the wavelengths of the lines of the hydrogen spectrum. His formula matched the format of the empirical formula derived first by Balmer, modified by Rydberg and applied to find other groups of spectral lines. In one sense, he knew the answer to the problem and may not have produced his model without the preceding work.
Chadwick's discovery of the neutron followed the experiments of a number of scientists involving the bombardment of small atoms with alpha particles, producing unknown radiation. These physicists had unsuccessfully applied to their results the accepted physics laws of conservation of mass, momentum and energy developed much earlier. Chadwick also had the benefit of the earlier suggestion by Rutherford that the nucleus contained a neutral particle. He repeated the experiments producing the unknown radiation and based on all the preceding work, showed that a neutral particle accounted for the results.
Fermi achieved the first nuclear fission reaction although he was unaware that he had done so. He and his team were working bombarding heavy elements with neutrons in an attempt to produce transuranic elements. This work would not have been possible without the understanding that there were neutral particles in the nucleus that could be emitted on bombardment with alpha particles. He later provided the analysis that explained the energy decay curves for beta decay using the neutrino that had first been suggested by another scientist, Pauli. During World War II, Fermi with many others set the first chain reaction using the fission of uranium – this reaction had been explained by 2 other physicists as fission, the splitting of the uranium nucleus. 8
It can be seen that each of the famous scientists above built on the work of other scientists who had previously made important breakthroughs.