PC301

THREE HOURS

A list of constants is enclosed.

UNIVERSITY OF MANCHESTER

General Physics I

21st May 1998, 2.00 p.m. - 5.00 p.m.

THREE HOUR CANDIDATES
Answer **ALL** questions

TWO HOUR CANDIDATES
(Maths/Physics and Chemistry/Physics)
Answer questions 1 - 10 inclusive

Electronic calculators may be used, provided that they cannot store text.

The numbers indicate the relative weights of the different parts of each question and do **NOT** represent a marking scheme.

P.T.O.

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1. Estimate the mean free path of argon atoms when the gas is at 300 K and 2 atmospheres pressure. (The diameter of an argon atom is 4×10^{-10} m).

2. Estimate the orbital period for a satellite in a low altitude Earth orbit.

3. A reversible heat engine takes heat from a bath at a fixed temperature, and when it supplies heat to a bath at 300 K it operates at 25% efficiency. What efficiency would it achieve if the lower temperature bath were at 77 K?

4. A projectile explodes into two pieces at the top of its trajectory, a distance L measured horizontally from its launch point. The two resulting fragments have masses $\frac{1}{4}$ and $\frac{3}{4}$ of the original mass and emerge horizontally from the explosion with the small fragment landing back at the original launch point. How far from the original launch point does the larger fragment land?

5. An electron at rest is accelerated through a potential of 1.02×10^6 V. What is its final velocity?

6. The metal rotor blade of a helicopter has a length of 5 m from hub to tip and rotates at a frequency of 500 revs per min. The axis of rotation of the blade is at an angle of 30° with respect to the direction of the Earth's magnetic field which has an intensity of 0.4×10^{-4} Tesla. Calculate the magnitude of the induced emf between the hub and the tip of the blade.

7. An electron is confined to a cubical well of side 1.0 nm by infinite potential walls. Determine the energies in eV, relative to the bottom of the well, of the lowest two states.

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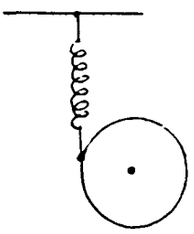
8. A recent measurement of the gravitational constant gave the result G = 6.67259 ± 0.00001 × 10^{-11} Nm^2 kg^{-2}. Find the corresponding uncertainty in g due to the uncertainty in G. Estimate the increase in height at the Earth's surface which would give a change in g of this amount.

9.

The side of a thin disk of mass m and radius r, pivoted at its centre, is attached to the end of an unstretched spring of force constant k, as shown. The disk is rotated slightly and released. Calculate the period of small oscillations.



10. An argon ion laser beam at a wavelength of 515 nm is chopped by a shutter to produce pulses of 10^{-10} s duration. Calculate for the pulses: (a) the frequency bandwidth, (b) the wavelength spread and (c) the coherence length.

11. A torsional oscillator consists of a long thin rod suspended horizontally on a fibre. Use the method of dimensions to show how the resonant frequency of the oscillator depends on the torsional constant of the fibre, and on the mass and the length of the rod.

12. A particle of spin $S = \frac{1}{2}$ is bound in a central potential with orbital angular momentum quantum number $L = 2$. It is subject to a spin-orbit potential

$$V_{LS} = \lambda \, \hat{\underline{L}} \, . \, \hat{\underline{S}}$$

Calculate the angular momentum and energy of each level in the resulting multiplet.

13. Consider the boundary between two dielectric media. Derive the continuity conditions for the normal component of the $\underline{D}$ field and the parallel component of the $\underline{E}$ field in the presence of a surface charge.

14. A sample contains N spin 1/2 non-interacting paramagnetic ions per unit volume. These can take up one of two orientations with respect to the direction of an applied magnetic field B. If the effective magnetic moment of each ion is μ, obtain an expression for the average magnetic moment per unit volume of the sample at a temperature T.

15. A photon of wavelength 850 nm is absorbed by a rubidium atom of atomic mass 85 travelling in the opposite direction. Estimate the reduction in speed of the atom that results from this process.
