Name: Alan's Copy
Student Number:

PHYSICS 1BA3

DAY CLASS — Dr. A. Chen
DURATION OF EXAMINATION: 2 hours — Dr. J.C. Waddington
McMaster University FINAL Examination — April 2003

THIS EXAMINATION PAPER INCLUDES 12 PAGES AND 10 QUESTIONS. YOU ARE RESPONSIBLE FOR ENSURING THAT YOUR COPY OF THE PAPER IS COMPLETE. BRING ANY DISCREPANCY TO THE ATTENTION OF YOUR INVIGILATOR. ALL QUESTIONS ARE OF APPROXIMATELY EQUAL VALUE.
THE CASIO-FX991 CALCULATOR IS PERMITTED.

Special Instructions: All questions should be answered. All solutions should be written down in the spaces provided. If you run out of space, you may use the blank page that has been provided at the end of the examination paper. Be sure to clearly indicate where the answer has been continued. Complete solutions to problems should be presented. If an answer is given without the preceding steps, you may be awarded less than full marks even if the answer is correct.

gravitational field at earth's surface	$g = 9.81\ m/s^2$
speed of light in vacuum	$c = 3.00 \times 10^8\ m/s$
Planck's constant	$h = 6.63 \times 10^{-34}\ J\text{-}s$
charge of electron	$-e = -1.602 \times 10^{-19}\ C$
mass of the electron	$m_e = 9.109 \times 10^{-31}\ kg$
mass of the hydrogen atom	$m_H = 1.67353 \times 10^{-27}\ kg$
mass of the neutron	$m_n = 1.67492 \times 10^{-27}\ kg$
Coulomb's law constant	$k_e = [4\pi\varepsilon_0]^{-1} = 9 \times 10^9\ Nm^2/C^2$
Bohr radius	$a_0 = 0.0529\ nm$
$\int \sin(ax)\,dx = -(\cos(ax))/a$	$amu = 931.494013\ MeV/c^2$
$\int \sin^2(ax)\,dx = x/2 - (\sin(2ax))/(4a)$	
$\int \cos^2(ax)\,dx = x/2 + (\sin(2ax))/(4a)$	

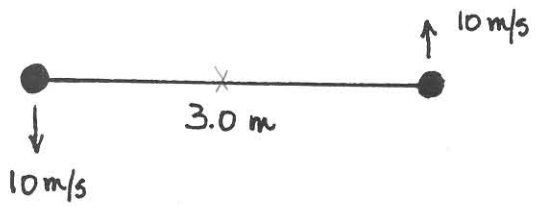
Moment of inertia of a long thin uniform stick about its middle = $M L^2 / 12$
Moment of inertia of a disk about its axis = $M R^2 / 2$
Moment of inertia of a ring about its axis = $M R^2$

$\mathbf{I} = \mathbf{I}_{cm} + m d^2$
$\mathbf{I} = \int r^2\,dm$
$V = k_e q / r$
$\mathbf{F} = k_e q_1 q_2 / r^2$
$\mathbf{F} = q\,\mathbf{v} \times \mathbf{B}$
$\mathbf{F} = q\,\mathbf{E}$
$\mathbf{F} = m\,\mathbf{a}$
$L = I\,\omega$
$\tau = I\,\alpha$
$N = N_0\,e^{-\lambda t}$
$\lambda_{max}\,T = 2.898 \times 10^{-3}\ K\text{-}m$

$\Delta x\,\Delta p_x >= h/4\pi$
$\lambda' - \lambda_0 = h(1 - \cos\theta)/(m_e c)$
$E_n = -13.6/n^2\ eV$ $\quad r_n = n^2 a_0$
$E_n = n^2 h^2/(8\,m\,L^2)$
$\lambda = h/p$
$c = f\lambda$
$E = h f$
$hf = \Phi + K_e^{max}$
$E_b = (Z m_H + N m_n - M_A)\,c^2$
$\lambda\,T_{1/2} = 0.693$

Continued on next page...

1. Two skaters, each of mass 50 kg, are holding onto the ends of a light pole of length 3.0 m. The skaters have equal and opposite velocities of 10 m/s, such that they move along a circular trajectory with a diameter equal to the length of the pole. Assume frictionless ice.



(a) By pulling on the pole, the skaters reduce their separation to 1 m. What is the angular speed then?

(b) Calculate the initial and final kinetic energy of the system. From where does the change come?

Continued on next page

2. A slender rod with length L has a mass per unit length that varies with distance from the left-hand end, where x = 0, according to dm/dx = λ = Ax, where A is a constant with units of kg /(m.) → m^2

(a) Calculate the total mass of the rod in terms of A and L.

(b) Use the expression $I = \int r^2 dm$ to calculate the moment of inertia of the rod for an axis at the left-hand end, perpendicular to the rod. Use the expression you derived in part (a) to express I in terms of M and L.

(c) How does your result compare to that of a uniform rod? Explain this comparison.

Continued on next page

3. A rod with uniform charge density λ lies along the x-axis with one end at x = a and the other at $x \to \infty$. Starting from Coulomb's law, find the electric field at the origin.

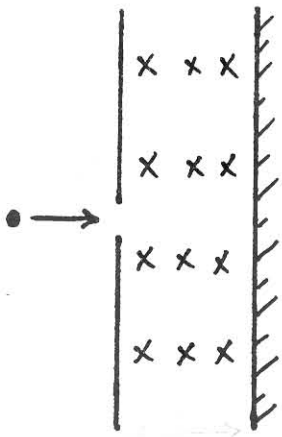
Continued on next page

4. (a) In the Bohr model of the hydrogen atom, an electron circles a proton at a radius of 5.3×10^{-11} m. How fast must the electron be moving if the centripetal force is to be supplied by the Coulomb attraction?

(b) The nucleus of the radium atom has a charge of + 88e and a radius of about 7×10^{-15} m. With what speed must a proton be shot at the atom if it is to reach a radius of 10×10^{-15} m? Ignore the effect of the radium's atomic electrons.

Continued on next page

5. A particle with positive charge q and mass m is shot with kinetic energy K into a region between two plates as shown in the figure. If the magnetic field between the plates is B and as shown (pointing into the page), how large must B be if the particle is to avoid a collision with the opposite plate located a distance L from the two plates? Sketch the particle's trajectory on the figure below.



Continued on next page

6. (a) Describe what is meant by blackbody radiation. Illustrate this with a figure that shows how the spectrum changes with temperature. What was Max Planck's contribution to understanding this spectrum?

(b) If the sun has a surface temperature of 6000 degrees K, what is the frequency of the most intense light emitted?

Continued on next page

7. An electron is accelerated through a potential of 1 Volt.

(a) What is its wavelength?

(b) The position of this electron is determined to $\pm 10^{-9}$ m. Quantitatively what effect does this have on its wavelength?

Continued on next page

8. A pulsed ruby laser emits light at 700 nm. A 10^{-11} sec pulse containing 3.00 J of energy is emitted.

(a) Calculate the physical length of the pulse as it travels through space.

(b) What is the energy of each photon?

(c) Calculate the number of photons in the pulse.

Continued on next page

9. A particle with mass M is confined to a one-dimensonal box with infinite, impenetrable sides and width L. Answer all parts in terms of L, M, and h.

(a) What is the smallest energy that the particle could have?

For the following parts of the question, the wavefunction of the particle may be described by $\psi(x) = \sqrt{\frac{2}{L}} \sin(\frac{2\pi x}{L})$.

(b) Make a sketch of the probability density of the particle.

(c) What is the wavelength of the particle?

(d) This particle decays to its ground state by emitting a photon. What is the wavelength of the photon?

Continued on next page

10. (a) A radioactive material initially consists of 10^8 atoms. It was found that it decays at a rate of 10^6 disintegrations/s. How many atoms have not decayed 200 seconds later?

(b) An archeologist finds a buried burnt piece of wood. Describe how she might determine how old this sample is.

Continued on next page

Blank page for extra work.

C B ABA

THE END