# General Physics Exam (July 10, 1998)

Note: There are 20 blanks from **A** to **T** in this test. Each blank gets 5 points. Please list results to each blank on the first page of your answer sheet. Formal procedures which are not required start from the second page.

1. A stone of weight w is thrown vertically upward into the air with an initial speed v_0. A constant force f_0 due to the air resistance acts on the stone throughout its flight. Find **A** the speed of the stone upon impact with the ground.
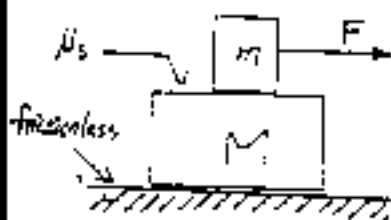
2. A mass m is put on top of a mass M and the assembly of m and M is placed on a frictionless horizontal surface as shown in figure. A minimum horizontal force F must be applied on m in order to make m slip on M. Find **B** the coefficient of static friction between m and M. The gravitational acceleration is g.
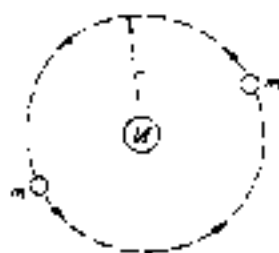
3. A certain triple-star system consists of two small stars, each of mass m, revolving about a larger central star, mass M, in the same circular orbit. The two small stars stay at opposite ends of a diameter of a circular orbit of radius r. Express **C** the period of revolution of the small stars. The gravitational constant is G.
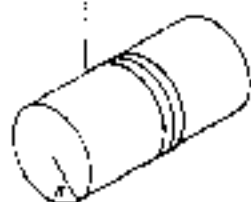
4. A solid cylinder of mass m and radius R unwinds on a vertical string. Find **D** the linear acceleration of CM, and **E** the tension on the string. The gravitational acceleration is g.
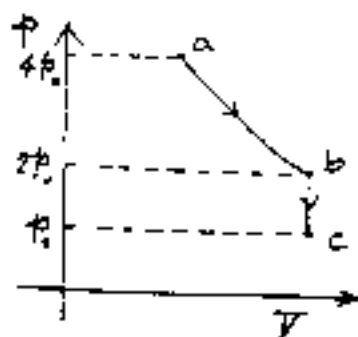
5. One mole of a monoatomic ideal gas goes through the processes as shown in the $p - V$ diagram. Here ab is an isothermal process at temperature T, and bc is a constant volume process. Let the gas constant be R. Find: **F** the work done by the gas during $a \to b$, **G** the heat absorbed or released by the gas during $b \to c$, and **H** the change in entropy of the gas during $a \to c$.

6. In a $NaCl$ crystal, Na^+ and Cl^- ions lie alternatively on a three-dimensional cubic array. The nearest neighbor of any ion is at a distance a. The permitivity constant is ϵ_0. Calculate **I** the potential energy of a center Na^+ ion, by including array with distance $d < 2a$.
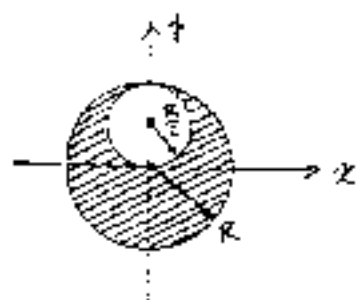
7. A sphere with radius R has a spherical hollow with radius $R/2$ as shown in figure. The surface of the hollow touches the outside surface of the sphere and passes through the center of the sphere. A total charge of Q is uniformly distributed on the object. What is **J** the magnitude, and **K** the direction of the field within the cavity?
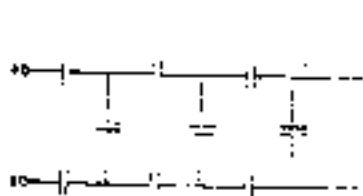
8. The pattern of connections between identical capacitors as shown in figure is continued indefinitely. Each capacitor has $1\,\mu F$. What is **L** the equivalent capacitance between the terminals a and b?

9. An infinitely long thin metal plate of width w carrries a current I as shown. Find **M** the magnetic field at point Q at a distance L from the edge. Let the permeability constant be μ_0.

10. In the circuit shown in figure. $V_0 = 10\ V$, $R_1 = 20\ \Omega$, $R_2 = 5\ \Omega$, and $L = 4\ H$. Before the switch S is closed, the current in any part of the circuit is zero. S is then suddenly closed at $t = 0$. Find: **N** the current I_1 at $t = 0$, **O** the current I_1 at $t = \infty$, and **P** the current I_L at any time $t > 0$.
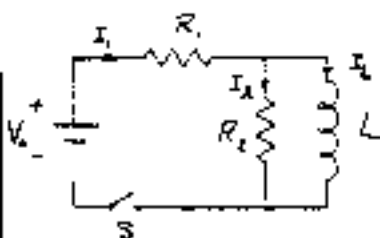
11. White light is incident normally on a lens (refraction index $n=1.5$) that is coated with a film of MgF_2 ($n = 1.38$). Find **Q** the minimum thickness of the film such that yellow light 550 nm (in air) will be missing in the reflected light?

12. A space center on earth tracks an approaching spaceship moving at velocity $0.2\,c$. If the radar signal has a frequency of $1000\,MHz$, what is __R__ the frequency of the reflected signal measured on earth?

13. An alpha particle of mass m is trapped in an infinite potential well of width l. What is __S__ the ground state energy of the alpha particle? Let the Planck constant be h.

14. A light beam travels at angle θ' to the x'-axis of frame S', which moves at velocity v in the $+x$ direction of frame S. What is __T__ the angle θ of the light beam to the x-axis observed in frame S?