

[Answer can be in either English or Chinese]

- (5%) A boy tosses a ball up in the air. What is the direction of the acceleration of the ball when it reaches the top?
- (10%) The mean free path of a gas is given by $1/(\eta\sigma)$, where η is the number density, and σ is the collision cross-section. Estimate the order of magnitude, in meters, of the mean free path for the air molecules at room temperature. (1atm= 10^5 Pa; universal gas constant, $R=8.31$ joule/K, Avogadro's number $N_0=6.02\times 10^{23}$ per mole)
- (5%) A student makes 10 one-second measurements of the disintegration of a sample of long-lived radioactive isotope and obtains the following values: 3, 0, 2, 1, 2, 4, 0, 1, 2, 5. How long should the student count to establish the decay rate to an uncertainty of 1 percent?
- Consider a non-conducting ring with uniform charge density λ and radius b (Fig 1). The potential at infinity is 0. (a) (5%) How much work is required to move a point charge $-q$ from P_1 to P_2 ? (b) (10%) Consider the mass of the charge is m . Find the oscillation frequency of the point charge if it is released at $z \ll b$ above the center of the ring. (c) (10%) Continued from (b), when the point charge is at the center of ring, we remove the ring, and apply a uniform magnetic field H at an angle θ to the symmetry axis P_1P_2 . What is the radius of the point charge's circular motion?
- Consider an attempt to produce a very low temperature using a Carnot cycle at fixed parameters V_a, V_b, V_c, V_d (Fig 2). The reservoirs are at temperatures $T_L < T_H$. (a) (10%) How much heat is removed from the cold reservoir during each cycle? (b) (10%) If the heat capacity of the reservoir is C , what is the temperature of the cold reservoir after n cycles?
- (10%) A Doppler radar is composed of a transmitter and a receiver as in Fig 3. Consider an object moving toward the radar at constant velocity u . If the velocity of the wave is $v \gg u$, the source frequency is f_s , and the reflected frequency received by the radar is f_r , what is the velocity of the object in terms of f_s and f_r ?
- Two identical blocks of mass m are connected by a spring with spring constant k (Fig 4). The combination is suspended, at rest, by a string to the ceiling. The string breaks suddenly. (a) (5%) What is the acceleration of the upper block immediately after the string breaks? (b) (10%) What is the oscillation frequency of the system after the string breaks?
- (10%) A broad beam of light of wavelength λ is sent directly downward through a glass plate ($n=1.5$) that, with a plastic plate ($n=1.2$), forms a thin wedge of air (Fig 5). An observer looking down through the top plate sees k dark fringes, with dark fringes at A and B. What is the width of the wedge at B?

Figures:

